Total Maximum Daily Load (TMDL) Development for Cedar Creek, Hall/Byers Creek, and Hutton Creek

Aquatic Life Use (Benthic) Impairment

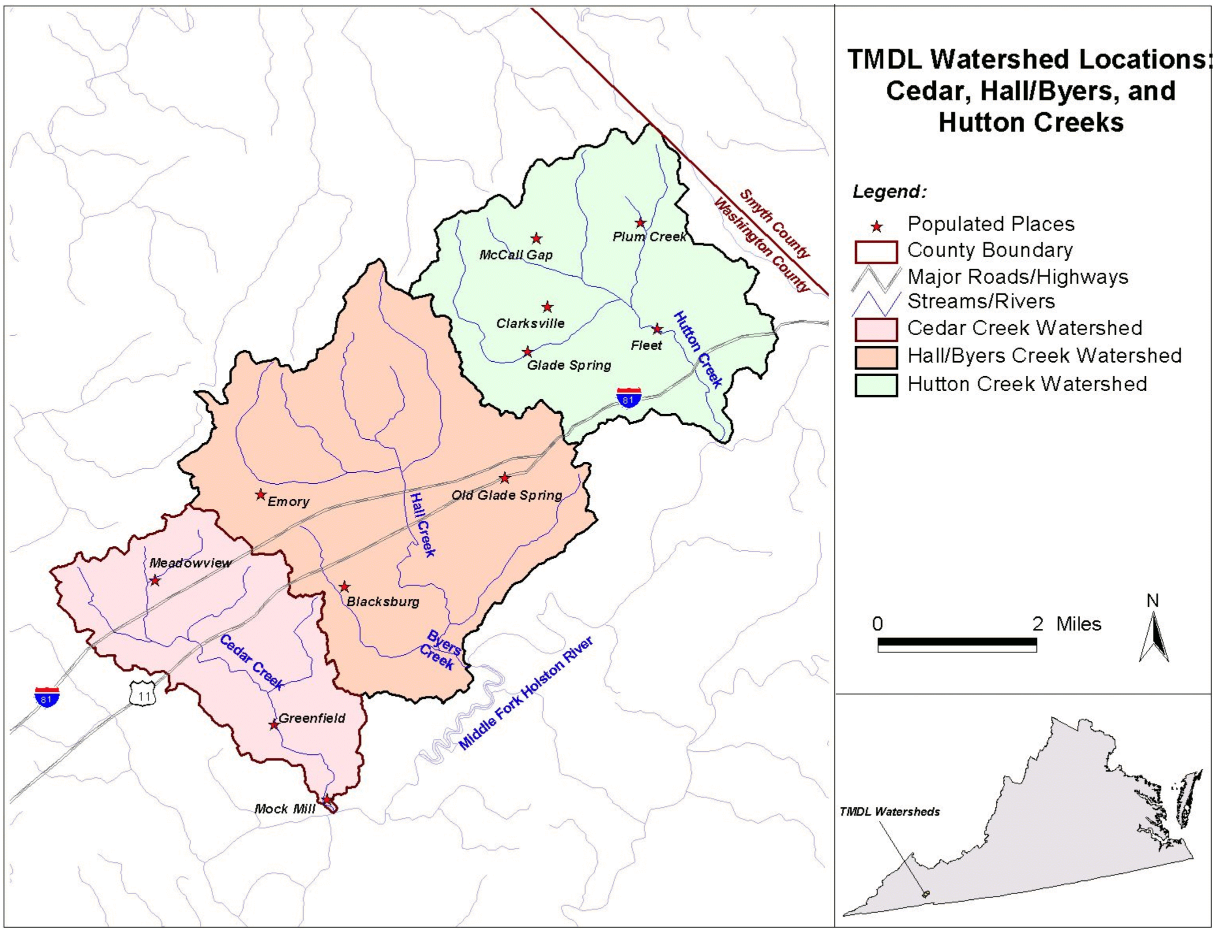

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Table of Contents

List of Tables

List of Figures

Executive Summary

Background

The Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds are located in Washington County, Virginia, in the Middle Fork Holston River Basin (USGS Hydrologic Unit Code, 02070005) (Figure 1.1). These watersheds are contiguous to one another and are located approximately 15 miles northeast of Abingdon, Virginia. The waterbody identification code (WBID, Virginia Hydrologic Unit) for these streams is VAS-O05R.

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 2002). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the EPA's Rapid Bioassessment Protocol (RBP) ranking is either moderately or severely impaired. As a result, these streams were listed as impaired due to violations of the general standard (aquatic life) on the 1998 303(d) list.

Water quality data analyses and field observations indicate that the primary cause of the benthic community impairment in these streams is excessive sedimentation. In order to improve water quality conditions that have resulted in benthic community impairments, Total Maximum Daily Loads (TMDLs) were developed for each impaired stream, taking into account all sources of sediment in the watersheds, plus a margin of safety (MOS). Sediment TMDLs were developed for Cedar Creek, Hall/Byers Creek, and Hutton Creek.

Upon implementation, the TMDLs will ensure that water quality conditions relating to benthic impairment will meet the allowable loadings estimated by use of a reference watershed (a non-impaired watershed with characteristics similar to those of the impaired watersheds). As with other pollutants, if toxic chemicals are found to exist at toxic levels in these streams in the future, then TMDLs will be developed for these constituents as well.

Sources of Sediment

Sediment sources can be divided into point and nonpoint sources. There are four point sources of sediment in the impaired watersheds. Two of the sediment point sources are located in the Cedar Creek watershed, one is located in the Hall/Byers Creek watershed, and one is located in the Hutton Creek watershed (Table 1).

Table 1. Sediment point source facilities located in the impaired watersheds

Stream	Facility Name	VPDES Permit No.	Discharge Type	Design Flow (MGD)	Permitted Concentration (mg/L)	TSS Load (lbs/year)
Cedar Creek	Meadowview Elementary School	VA0030589	Municipal	0.016	30	1,461.17
	Dillow's Shop and Wash	VA0071366	Municipal/ Industrial	0.004	30	328.76
Hall/Byers Creek	Emory-Meadowview WWTP	VA0087378	Municipal	0.630	30	57,533.49
Hutton Creek	Smith Residence, SFH STP	VAG400181	Single Family House	<.001	30	91.32

Sediment loads in the impaired watersheds are primarily contributed by nonpoint sources. The major source of sediment in these watersheds is agricultural land. Agricultural lands can contribute excessive sediment loads through erosion and build-up/washoff processes. Agricultural lands are particularly susceptible to erosion due to less vegetative coverage. Streambank erosion has also been noted as a potential source of sediment in these watersheds.

Modeling

TMDLs were developed using BasinSim 1.0 and the GWLF model. GWLF is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance totals that are summed to give monthly values.

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. The USGS streamflow gage (03473500) was used in a paired watershed approach to calibrate hydrology for Cedar Creek, Hall/Byers Creek, and Hutton Creek. Flow data were available from this gage for the time period: October 1, 1987 - September 30, 1989. For the reference watershed, Walker Creek, hydrology was calibrated using the USGS streamflow gage, 03173000. Data were available from this gage for the time period: 1980 - 2000. The impaired and reference watersheds were calibrated for the respective time period. The calibration period covered a range of hydrologic conditions, including low- and high-flow conditions as well as seasonal variations. The calibrated GWLF model adequately simulated the hydrology of the four impaired watersheds.

TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. Numeric endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Virginia does not currently have numeric criteria for sediment.

Therefore, a reference watershed approach was used to determine the primary benthic community stressors and to establish a numeric endpoint for sediment. This approach is based on selecting a non-impaired watershed that shares similar land use, ecoregion, and geomorphological characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to attain its designated uses. Walker Creek was chosen as the reference watershed and any reductions of sediment from the impaired waterbodies was based on the reference loads of sediment in the Walker Creek watershed.

Existing Conditions

Impaired and reference watershed models were calibrated for hydrology using different modeling periods and weather input files. To establish baseline (reference watershed) loadings for sediment, the GWLF model for Walker Creek was run with the same weather input file that was used for the impaired watershed simulations. This step was needed to standardize the modeling period and weather conditions (which affect pollutant loading rates) between impaired and reference watersheds for the calculation of TMDLs. In addition, the total area for the reference watershed was reduced to be equal to its paired target watershed. This was necessary because watershed size influences sediment delivery to the stream and other model variables.

The 9-year (April 1990 - March 2000) mean for sediment was determined for each land use/source category in these watersheds. This modeling period was used, after calibration, to represent a broad range of recent weather and hydrologic conditions.

Transport loss estimates were used to determine the total sediment load contributed by point sources in these watersheds. The transport loss for each of the watersheds was based on the sediment delivery ratio for each watershed. The inverse of this ratio was used because point sources loads are directly contributed to the stream.

Margin of Safety

While developing allocation scenarios for the TMDL, an explicit margin of safety (MOS) of 10 percent was used. Ten percent of the reference sediment load was calculated and added to the sum of the load allocation (LA) and wasteload allocation (WLA) to produce the TMDL. It is assumed that a MOS of 10 percent will account for any uncertainty in the data and the computational methodology used for the analysis, as well as provide an additional level of protection for designated uses.

Allocation Scenarios

Load or wasteload allocations were assigned to each source category in the watersheds. The recommended scenario for each stream (Table 2) is based on maintaining the existing percent load contribution from each source category. Two additional scenarios were considered, but due to the minimal amount of sediment loading from urban lands in each watershed, options were limited to the recommended scenario. In this scenario, loadings from certain source categories were allocated according to their existing loads. For instance, sediment loads from forest lands represent the natural condition that would be expected to exist; therefore, the loading from forest lands was not reduced.

Also, sediment loads from point sources were not reduced because these facilities are currently meeting their pollutant discharge limits and other permit requirements and because these loads were insignificant as compared with other sources. Current permit requirements are expected to result in attainment of the WLAs as required by the TMDL. Point source contributions, even in terms of maximum flow, are minimal, therefore, no reasonable potential exists for these facilities to have a negative impact on water quality and there is no reason to modify the existing permits. Note that the sediment WLA values presented in the following tables represent the sum of all point source WLAs in each watershed, minus instream transport loss.

Table 2. Recommended sediment allocations for Cedar Creek, Hall/Byers Creek, and Hutton Creek

	Cedar Creek		Hall/Byers Creek		Hutton Creek	
Source Category	Sediment Load Allocation (lbs/yr)	Sediment % Reduction	Sediment Load Allocation (lbs/yr)	Sediment % Reduction	Sediment Load Allocation (lbs/yr)	Sediment % Reduction
Cropland	1,750,144.95	38.20	2,487,658.85	34.00	1,805,246.28	26.04
Pasture/Hay	999,621.41	36.20	2,427,982.43	33.80	2,069,313.55	25.00
Transitional	12,172.20	0.50	0.00	0.00	N/A	N/A
Forest	19.59	0.00	91.44	0.00	75.59	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00
Urban (grouped pervious and impervious areas)	605.43	0.00	1,000.43	0.00	843.07	0.00
Groundwater	0.00	0.00	0.00	0.00	0.00	0.00
Point Sources (WLA)** Existing load minus transport loss	1,444.65	0.00	48,236.08	0.00	75.38	0.00
TMDL Load (minus MOS)	2,764,008.23		4,964,969.22		3,875,553.87	

**Note that the sediment allocations are at the mouth of the watershed*
***Note:WLAs represent the existing permitted load from each facility minus the estimated sediment transport loss. Therefore, the allocation load given for each point source facility is equal to the existing, permitted load (no reduction).*

The TMDLs established for these streams consist of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The sediment TMDLs were based on the total load calculated for the Walker Creek watershed (area adjusted to the appropriate watershed size).

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis.

TMDLs were calculated by adding reference watershed loads for each pollutant of concern together with point source loads to give the TMDL value (Table 3). The sediment WLA values presented in the following tables represent the sum of all point source WLAs in each watershed, minus instream transport loss.

Note that the VADCR land use coverage used in TMDL development did not account for the Holston River SWCD BMP implementation efforts in these watersheds to date. Many of these BMP activities, including riparian restoration efforts, have improved benthic conditions in the Three Creeks watersheds. It is expected that some reduction in sediment loading has already occurred due to this successful program.

Table 3. TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek

Watershed	Pollutant	TMDL (lbs/yr)	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	Overall %
Cedar Creek	Sediment	3,071,126.53	2,764,008.23	1,444.65 (*Meadowview Elementary School =1,179.31 Dillow's Shop and Wash =265.34*)	307,121.16	37.37
Hall/Byers Creek	Sediment	5,564,960.98	4,964,969.22	48,236.08 (*Emory-Meadowview WWTP =48,236.08*)	551,755.68	33.68
Hutton Creek	Sediment	4,306,346.62	3,875,553.87	75.38 (*Smith Residence, SFH STP = 75.38*)	430,717.37	25.48

*** Note that the overall % reduction is applied to the TMDL load exclusive of the MOS*

SECTION 1

INTRODUCTION

1.1 Background

1.1.1 TMDL Definition and Regulatory Information

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (USEPA 1991).

1.1.2 Impairment Listing

Cedar Creek, Hall/Byers Creek, and Hutton Creek are listed as impaired on Virginia's Section 303(d) Total Maximum Daily Load Priority List and Report due to violations of the State's water quality standards for fecal coliform bacteria and violations of the General Standard (Benthics) (VADEQ 1998 & 2002). Cedar Creek, Hall/Byers Creek, and Hutton Creek were initially placed on Virginia's Section 303(d) list in 1994 due to violations of the fecal coliform bacteria standard based on data collected by the Mt. Rogers Planning District Commission and published in 1991. These streams were also listed for partial support of the Aquatic Life Use based biological monitoring data collected by the Tennessee Valley Authority in 1993, 1994, and 1995. More recent biological monitoring data collected by the Tennessee Valley Authority and VADEQ on Cedar Creek, Hall/Byers Creek, and Hutton Creek indicate a possible improvement in the condition of the benthic community; however the official status of Cedar, Hall/Byers, and Hutton Creeks remain impaired due to non-attainment of the general standard.

All impaired segments begin at the headwaters and end at the confluence with the Middle Fork Holston River. Hall Creek is renamed as Byers Creek below the confluence with Tattle Branch. All information regarding Hall Creek is included with Byers Creek in this report, unless otherwise expressed. TMDLs for fecal coliform bacteria were developed by the Commonwealth of Virginia in October 2000 and approved by EPA in February 2001 (VADEQ and VADCR 2000). This report addresses the benthic community impairments on these streams.

1.1.3 Watershed Location

The Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds are located in Washington County, Virginia, in the Middle Fork Holston River Basin (USGS Hydrologic Unit Code, 02070005) (Figure 1.1). These watersheds are contiguous to one another and are located approximately 15 miles northeast of Abingdon, Virginia. The waterbody identification code (WBID, Virginia Hydrologic Unit) for these streams is VAS-O05R.

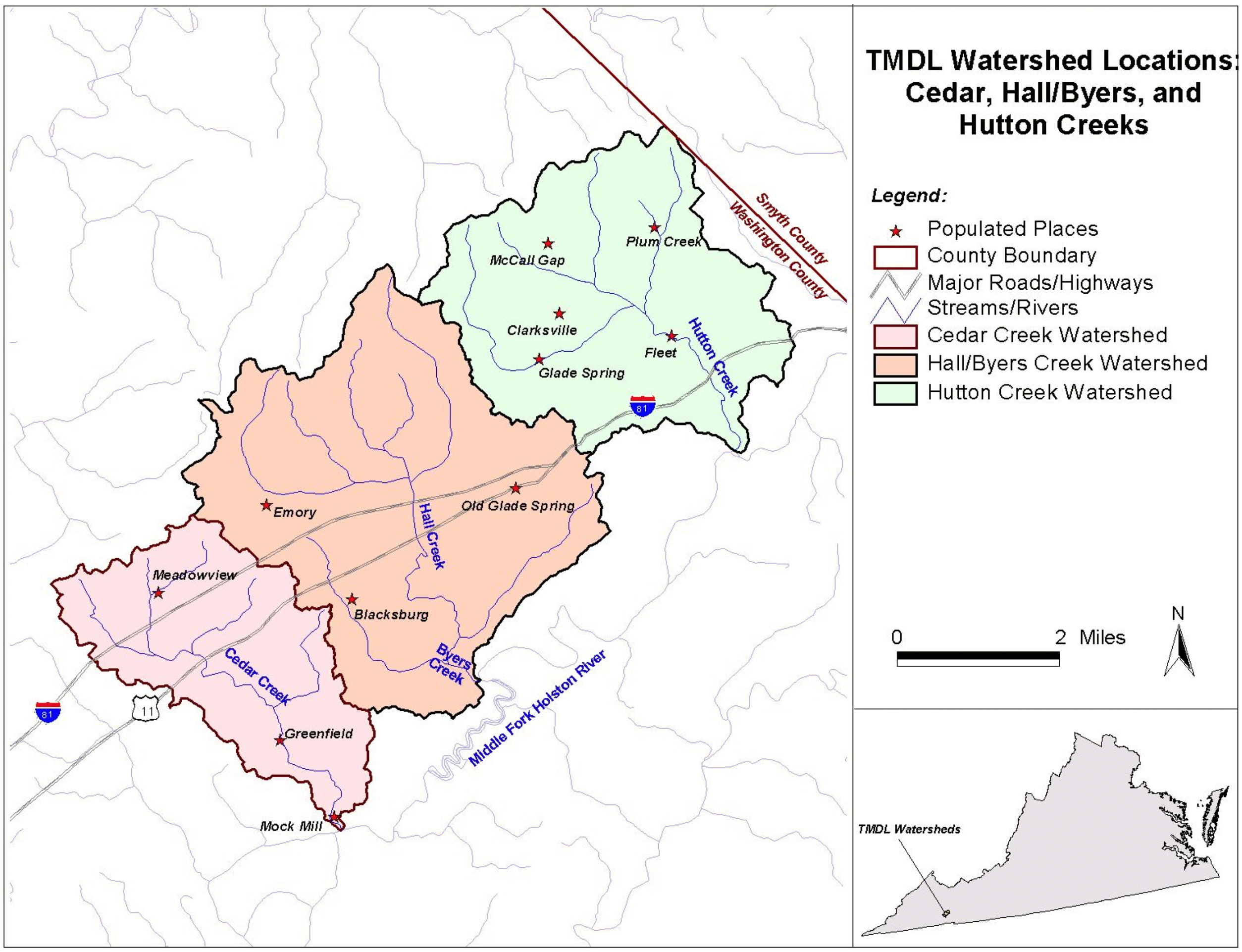

Figure 1.1 Location of TMDL watersheds

1.2 Applicable Water Quality Standards

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "Water quality standards" *means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§ 62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC § 1251 et seq.).*

1.2.1 Designation of Uses (9 VAC 25-260-10)

A. All state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).

Cedar Creek, Hall/Byers Creek, and Hutton Creek do not support the aquatic life designated use due to violations of the general (benthic) criteria (see Section 1.2.2).

1.2.2 Water Quality Criteria

General Criteria (9 VAC 25-260-20)

A. All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.

Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled.

1.3 Biomonitoring and Assessment

Direct investigations of biological communities using rapid bioassessment protocols, or other biosurvey techniques, are best used for detecting aquatic life impairments and assessing their relative severity (Plafkin et al. 1989). Biological communities reflect overall ecological integrity; therefore, biosurvey results directly assess the status of a waterbody relative to the primary goal of the Clean Water Act. Biological communities integrate the effects of different pollutant stressors and thus provide a holistic measure of their aggregate impact. Communities also integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions.

Many state water quality agencies use benthic macroinvertebrate community data to assess the biological condition of a waterbody. Virginia uses EPA's Rapid Bioassessment Protocol (RBP II) to determine the status of a stream's benthic macroinvertebrate community. This procedure relies on comparisons of the benthic macroinvertebrate community between a monitoring station and its designated reference site. Measurements of the benthic community, called metrics, are used to identify differences between monitored and reference stations. Metrics used in the RBP II protocol include taxa richness, percent contribution of dominant family, and other measurements that provide information on the abundance of pollution tolerant versus pollution intolerant organisms. Biomonitoring stations are typically sampled in the spring and fall of each year. The biological condition scoring criteria and the bioassessment matrix are discussed in the technical document, *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish* (Plafkin et al. 1989). The RBPII bioassessment scoring matrix is presented in Table 1.1.

Table 1.1 Bioassessment scoring matrix (Plafkin et al. 1989)

% Compare to Reference Score (a)	Biological Condition Category	Attributes
>83%	Non-Impaired	Optimum community structure (composition and dominance).
54 - 79%	Slightly Impaired	Lower species richness due to loss of some intolerant forms.
21 - 50%	Moderately Impaired	Fewer species due to loss of most intolerant forms.
<17%	Severely Impaired	Few species present. Dominant by one or two taxa. Only tolerant organisms present.
(a) Percentage values obtained that are intermediate to the above ranges require subjective judgement as to the correct placement.		

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 2002). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the RBP ranking is either moderately or severely impaired. As a result, these streams were listed as impaired due to violations of the general standard (aquatic life).

SECTION 2

BENTHIC TMDL ENDPOINT DETERMINATION

2.1 Reference Watershed Approach

Biological communities respond to any number of environmental stressors, including physical impacts and changes in water and sediment chemistry. According to Virginia's 2002 303(d) list, the probable causes of benthic impairment include nonpoint source runoff from agricultural and urban areas.

TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. Numeric endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Virginia does not currently have numeric criteria for nutrients (i.e. total phosphorus and total nitrogen), sediment, and other parameters that may be contributing to the impaired condition of the benthic community in these streams. A reference watershed approach was, therefore, used to determine the primary benthic community stressors and to establish numeric endpoints for these stressors. This approach is based on selecting non-impaired watersheds that share similar land use, ecoregion, and geomorphological characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to attain its designated uses. A multimetric macroinvertebrate index was used to define differences in the benthic communities in impaired and reference streams. Loading rates for pollutants of concern were determined for impaired and reference watersheds through modeling studies. Both point and nonpoint sources were considered in the analysis of pollutant sources and in watershed modeling. Numeric endpoints were based on reference watershed loadings for pollutants of concern and load reductions necessary to meet these endpoints were determined. TMDL load allocation scenarios were then developed based on an analysis of the degree to which contributing sources can be reasonably reduced.

2.2 Watershed Characterization

2.2.1 General Information

The Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds are located in Washington County, Virginia, in the Middle Fork Holston River Basin (USGS Hydrologic Unit Code, 02070005) (Figure 1.1). These watersheds are contiguous and are located approximately 15 miles northeast of Abingdon, Virginia. The waterbody identification code (WBID, Virginia Hydrologic Unit) for these streams is VAS-O05R. The total length of impaired streams is approximately 33 miles. The total area of the three watersheds is approximately 34 square miles.

2.2.2 Geology

Both streams are located in the Valley and Ridge physiographic province. The Valley and Ridge physiographic province is a belt of folded and faulted clastic and carbonate sedimentary rocks situated west of the Blue Ridge crystalline rocks and east of the Appalachian Plateaus. This area makes up part of the Great Valley subprovince, which extends from New York southwest to Alabama. This area is characterized by broad valleys with low to moderate slopes underlain by carbonate rocks. Limestone and dolomite (which are carbonate rocks) occur beneath the surface forming the most productive aquifers in Virginia's consolidated rock formations. The gently rolling lowland of the valley floor lies at an elevation of approximately 1000 feet above sea level. Sinkholes, caves, and caverns are common in the valley due to its karst (carbonate rock) geology.

2.2.3 Soils

Soils data were obtained from the Holston River Soil and Water Conservation District and the Washington County Soil Survey. These data were developed by the Natural Resources Conservation Service and are part of the national Soil Survey Geographic Database (SSURGO). Soil series hydrologic groups in each watershed are shown in Figure 2.1. The following soil series descriptions are based on NRCS Official Soil Descriptions (1998-2002).

The Frederick soil series occupies most of the land area in each impaired watershed. The Frederick series consists of very deep, well drained soils formed in residuum derived mainly from dolomitic limestone with interbeds of sandstone, siltstone, and shale. They are located on nearly level to very steep uplands. Permeability is moderate. Slopes range from 0 to 60 percent. Hydrologic soil group - B.

The Hagerstown series occupies valley floors and the adjacent hills. In some areas rock outcrops are common surface features. These are well drained soils with moderate permeability. Most slopes are less than 15 percent but range up to 45 percent. The soils developed in materials weathered from hard gray limestone of rather high purity. Hydrologic soil group - B.

The Marbie series consists of very deep, moderately well drained, slowly permeable soils along drainageways, on toeslopes, and in depressions. They formed in colluvium and alluvium weathered dominantly from limestone with inclusions of shale, siltstone, and fine-grained sandstone over residuum. Slopes range from 0 to 25 percent. Hydrologic soil group - C.

The Wyrick series consists of very deep, well drained, moderately permeable soils on benches, toeslopes, concave sideslopes and in upland depressions. They formed in colluvium and alluvium weathered dominantly from limestones with inclusions of shale, siltstone, and fine-grained sandstone over residuum. Slopes range from 2 to 25 percent. Hydrologic soil group - B.

The Timberville series consists of very deep, well drained soils formed in alluvial/colluvial materials. Permeability is moderate. The soils are subject to frequent flooding of very short duration during the period April thru October. Slopes range from 0 to 15 percent. Hydrologic soil group - B.

Other minor soils located in these watersheds include the following series: Atkins, Berks, Calvin, Clubcaf, Dekalb, Ebbing, Elliber, Ernest, Groseclose, Hayter, Litz, Macove, Mongole, Opequon, Shottower, Sindion, Speedwell, Tumbling, Weikert, and Westmoreland.

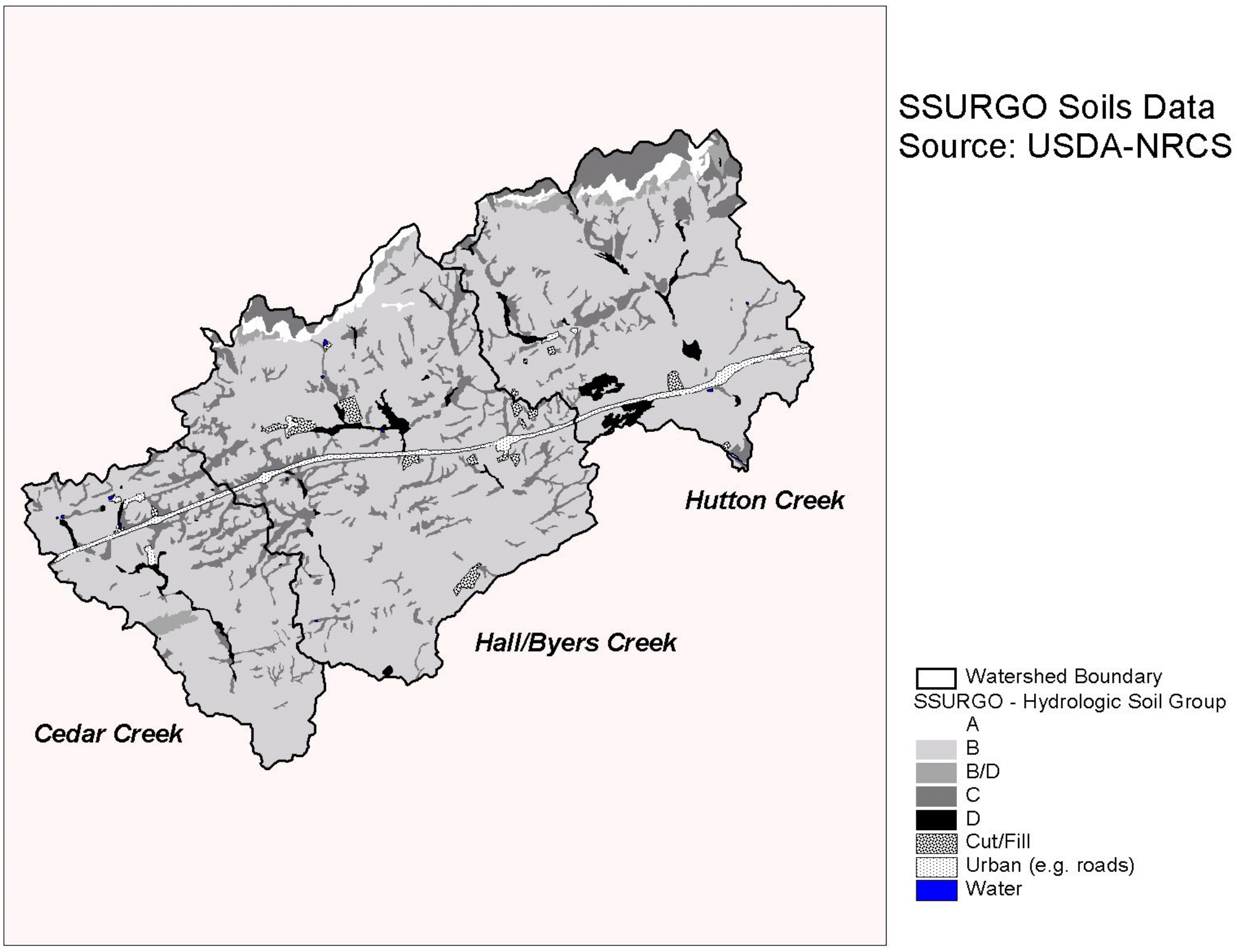

Figure 2.1 Soil hydrology groups for all soil series in TMDL watersheds

2.2.4 Climate

The area's climate is typical of other valley regions in Southwest Virginia. Weather data for these watersheds can be characterized using the Abingdon 3S meteorological station (NCDC), which is located approximately 15 miles to the southwest (period of record: 1969-2003). The growing season lasts from April 27 through October 20 in a typical year (SERCC 2003). Average annual precipitation is 47 inches with July having the highest average precipitation (4.86 inches). Average annual snowfall is 16.3 inches, most of which occurs in January and February. The average annual maximum and minimum daily temperature is 66.8°F and 41.7°F, respectively. The highest monthly temperatures are recorded in July (85.3°F - avg. maximum) and the lowest temperatures are recorded in January (23.4°F - avg. minimum).

2.2.5 Land Use

A GIS land use coverage was developed by the Virginia Department of Conservation and Recreation (VADCR) for these watersheds. These data were based on 1985 aerial photography provided by the Tennessee Valley Authority (TVA). This land use coverage was updated in 1999 for TMDL development through the efforts of VADCR, NRCS, and the New River Highlands RC&D staff. Land uses in each watershed include various urban, agricultural, and forest categories (Table 2.1 and Figure 2.2). Individual land use types were consolidated into seven broader categories that had similar erosion/pollutant transport attributes for modeling (Table 2.2). Note that this land use coverage has not been revised to include recent BMP implementation activities in these watersheds.

Table 2.1. Existing land uses by watershed (1999)

Land Use (Acres)	Cedar Creek	Hall/Byers	Hutton Creek	Total Area
Disturbed Area	3.2	0	0	3.2
Field Crop	16.5	14.2	0	30.7
Forest	354.5	1,961.80	1,636.20	3,952.40
Improved Pasture	1,274.70	2,772.90	962.7	5,010.20
Improved Pasture, Hayfield	35.8	94.4	74	204.2
Low Brush (10 ft)	22.5	29.6	10	62.1
Overgrazed Pasture	1,039.80	2,192.40	2,283.90	5,516.10
Overgrazed Pasture, Gullied	0	27.2	0	27.2
Poor Pasture, Gullied	200.1	380.8	604.9	1,185.80
Poor Pasture, little cover	0	0	83.4	83.4
Reclaimed Forest	0	10.9	0	10.9
Residential Trailer Park	118.1	155.3	15.4	288.9
Row Crop	87.9	112.4	0	200.3
Row Crop Strip	266.6	659.2	519.9	1,445.60
Row Crop, Gullied	482.1	219	159.7	860.7
Unimproved Pasture	258.4	206.4	67.6	532.5
Urban Land: Built-up area	468.4	1,154.50	730.5	2,353.40
Water	0.9	0	1.2	2.1
Total	4,629	9,991	7,149	21,770

Source: VA DEQ, 2000. Fecal Coliform TMDL for Cedar, Hall, Byers, and Hutton Creeks

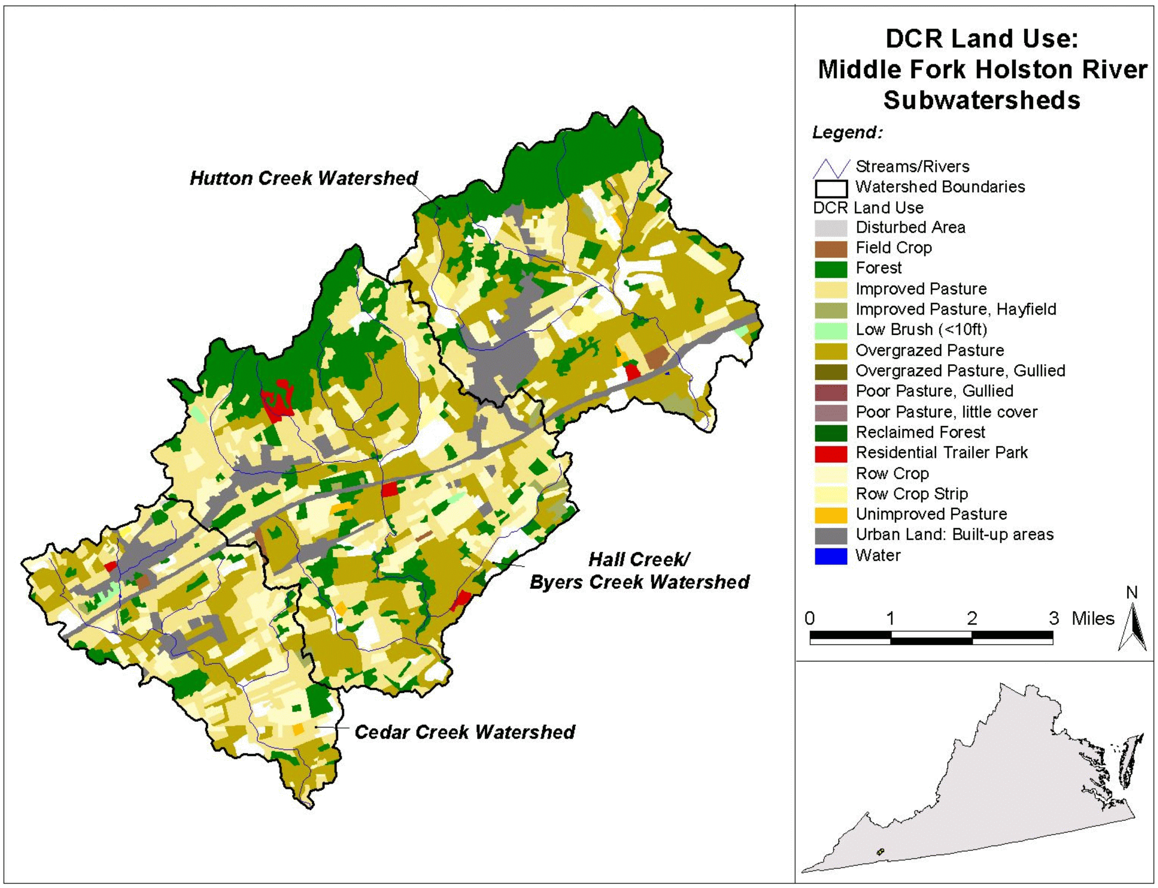

Figure 2.2 VADCR land uses in TMDL watersheds (updated 1999)

Table 2.2 VADCR land use categories and consolidated land uses

VADCR/TVA Land Use Categories	Consolidated Land Use	Cedar Creek Area (acres)	Hall/Byers Creek Area (acres)	Hutton Creek Area (acres)
Row Crop Row Crop Strip Row Crop Gullied Field Crop	Crop Land	853.1	1,004.8	679.6
Improved Pasture Improved Pasture, Hayfield Overgrazed Pasture Overgrazed Pasture, Gullied Poor Pasture, Little Cover Poor Pasture, Gullied Unimproved Pasture	Pasture/Hay	2,808.8	5,674.1	4,076.5
Disturbed Area	Transitional	3.2	0	0
Urban Land: Built-Up Area	High Intensity Residential	468.4	1,154.5	730.5
Residential Trailer Park	Low Intensity Residential	118.1	155.3	15.4
Forest Reclaimed Forest Low Brush	Forest	377	2,002.3	1,646.2
Water	Water	0.9	0	1.2

2.2.6 Ecoregion

These streams are located in the Valley and Ridge ecoregion - Level III classification 67 (Woods et al. 1999) (Figure 2.3). This ecoregion extends from Wayne County, Pennsylvania, southwest through Virginia. It is characterized by alternating forested ridges and agricultural valleys that are elongated, folded and faulted. The region's roughly parallel ridges and valleys have a variety of widths, heights, and geologic materials, including limestone, dolomite, shale, siltstone, and sandstone. The valleys generally fall into two types, those underlain by limestone and those underlain by shale. The nutrient rich limestone valleys contain productive agricultural land and tend to have few streams. By contrast, the shale valleys are generally less productive, more irregular, and have greater densities of streams. Most of the streams in the limestone valleys are colder and flow all year, whereas those in the shale valleys tend to lack flow in dry periods. Limestone areas commonly have numerous springs and caves. Present-day forests cover about 50 percent of the region. A diversity of aquatic habitats and species of fish exist in this ecoregion due to the variation in its components.

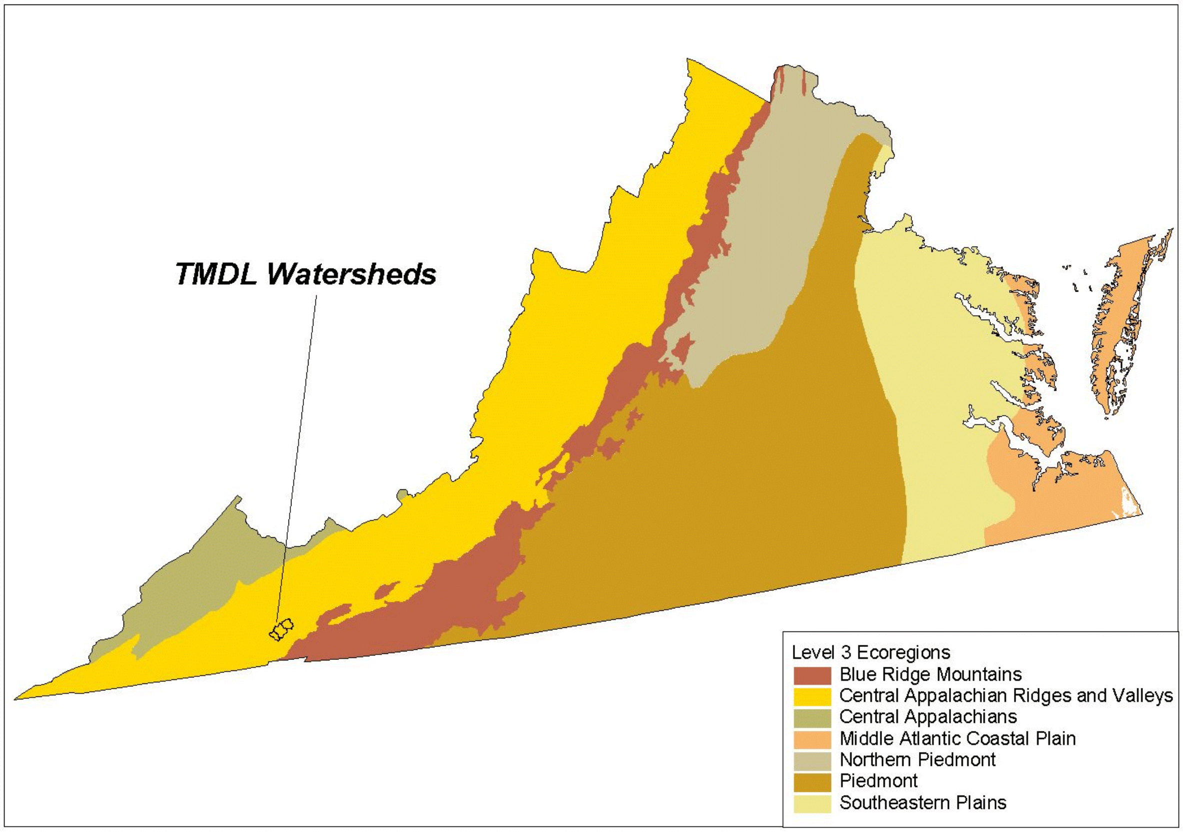

Figure 2.3 Virginia Level 3 Ecoregions

At a finer scale, the TMDL watersheds are primarily located in the Southern Limestone/Dolomite Valleys subecoregion - Level IV classification, 67f (Woods et al. 1999) (Figure 2.4). This subecoregion is characterized by broad, undulating, fertile valleys that are extensively farmed. Karst features including sinkholes and underground streams have developed in the underlying limestone/dolomite, and as a result, drainage density is low. Ordovician and Cambrian limestone and dolomite commonly underlie this ecoregion. Interbedded with these carbonates are other rocks, including shale, which give the ecoregion topographic and soil diversity. Streams tend to have gentle gradients, a perennial flow regime, and distinctive fish assemblages. Local relief typically ranges from 150-500 feet (mean sea level). The climate varies significantly because of the ecoregion's elevational and latitudinal range. The growing season varies from 175 to 180 days. Farming predominates, with scattered woodlands occurring in steeper areas. Natural vegetation mostly consists of Appalachian Oak Forest (dominated by white and red oaks) in the north and Oak/Hickory/Pine forest in the south.

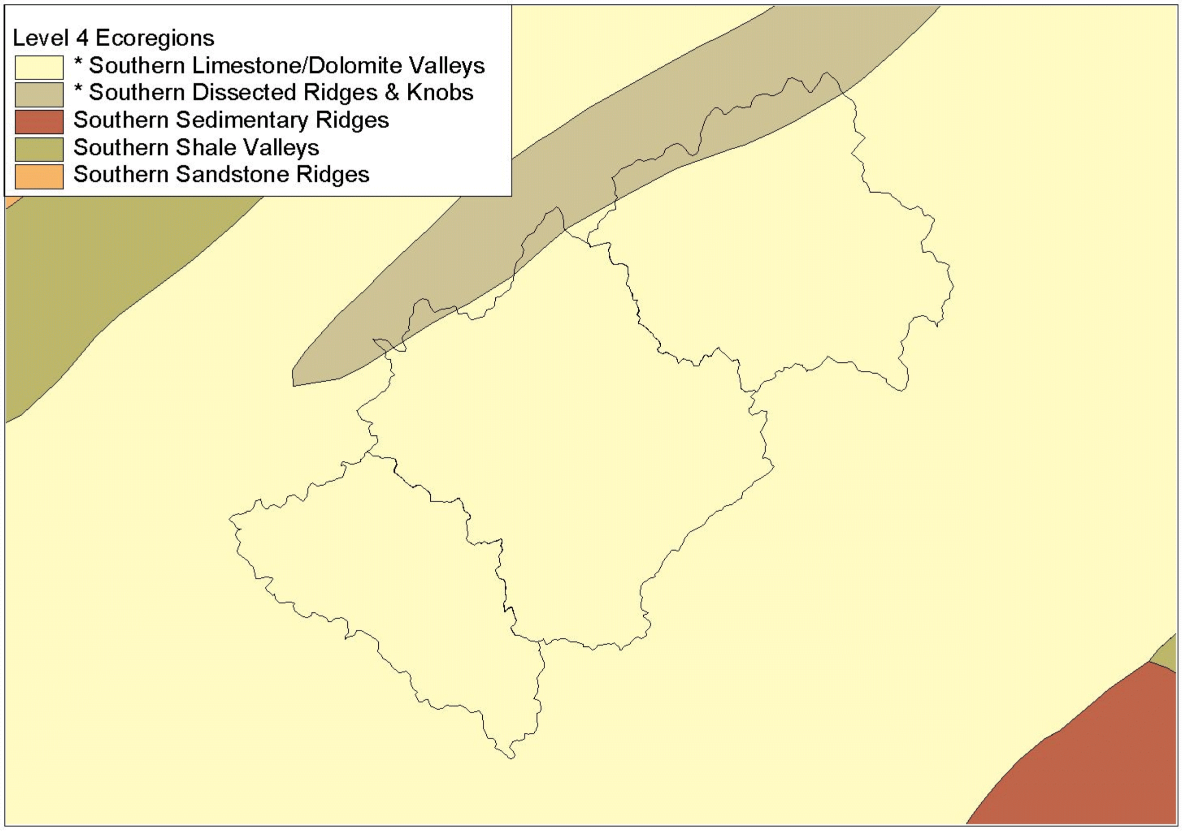

Figure 2.4 Virginia Level 4 Ecoregions

2.3 Reference Watershed Selection

The reference watershed selection process is based on a comparison of key watershed, stream and biological characteristics. The goal of the process is to select one or several similar, unimpaired reference watersheds that can be used to identify benthic community stressors and develop TMDL endpoints. Reference watershed selection was based on the results of VADEQ and TVA biomonitoring studies and comparisons of key watershed characteristics. A previous study of 141 unimpaired reference sites in the Valley and Ridge ecoregion provided the basis for watershed attribute comparisons. VADEQ also recommended several sites within this group for further examination. Data used in the reference watershed selection process for Cedar Creek, Hall/Byers Creek, and Hutton Creek are shown in Table 2.3.

Table 2.3 Reference watershed selection data

Biomonitoring Data	Ecoregion Coverages
Topography	Land use Distribution
Soils	Watershed Size
Water Quality Data	Point Source Inventory

Tetra Tech, VADEQ, and USEPA recently developed the Virginia Stream Condition Index (VaSCI), which provides a more detailed and reliable assessment of the benthic macroinvertebrate community in Virginia's non-coastal, wadeable streams (USEPA 2003a). This new multi-metric index was used to compare relative differences in the benthic community between impaired and reference streams. This index allows for the evaluation of biological condition as a factor in the reference watershed selection process and can be used to measure improvements in the benthic macroinvertebrate community in the future. VADEQ and TVA biomonitoring data were used to calculate the VaSCI scores shown in Table 2.4. The Walker Creek reference scores are shown for comparison.

Table 2.4 Bioassessment index comparison

Station ID	Stream	No. of Samples	VaSCI Scores
			Avg
Current TMDLs			
BYS000.08	Hall/Byers Creek	1	59
CED000.04	Cedar Creek	1	62
HTO000.07	Hutton Creek	1	72
Reference Streams			
WLK050.85	Walker Creek	2	75

2.4 Selected Reference Watershed

The Walker Creek watershed, delineated at the VADEQ biomonitoring station, was selected as the reference for these TMDLs (Figure 2.5). This determination was based on the degree of similarity between this stream and its associated watershed to the impaired streams and the VaSCI results.

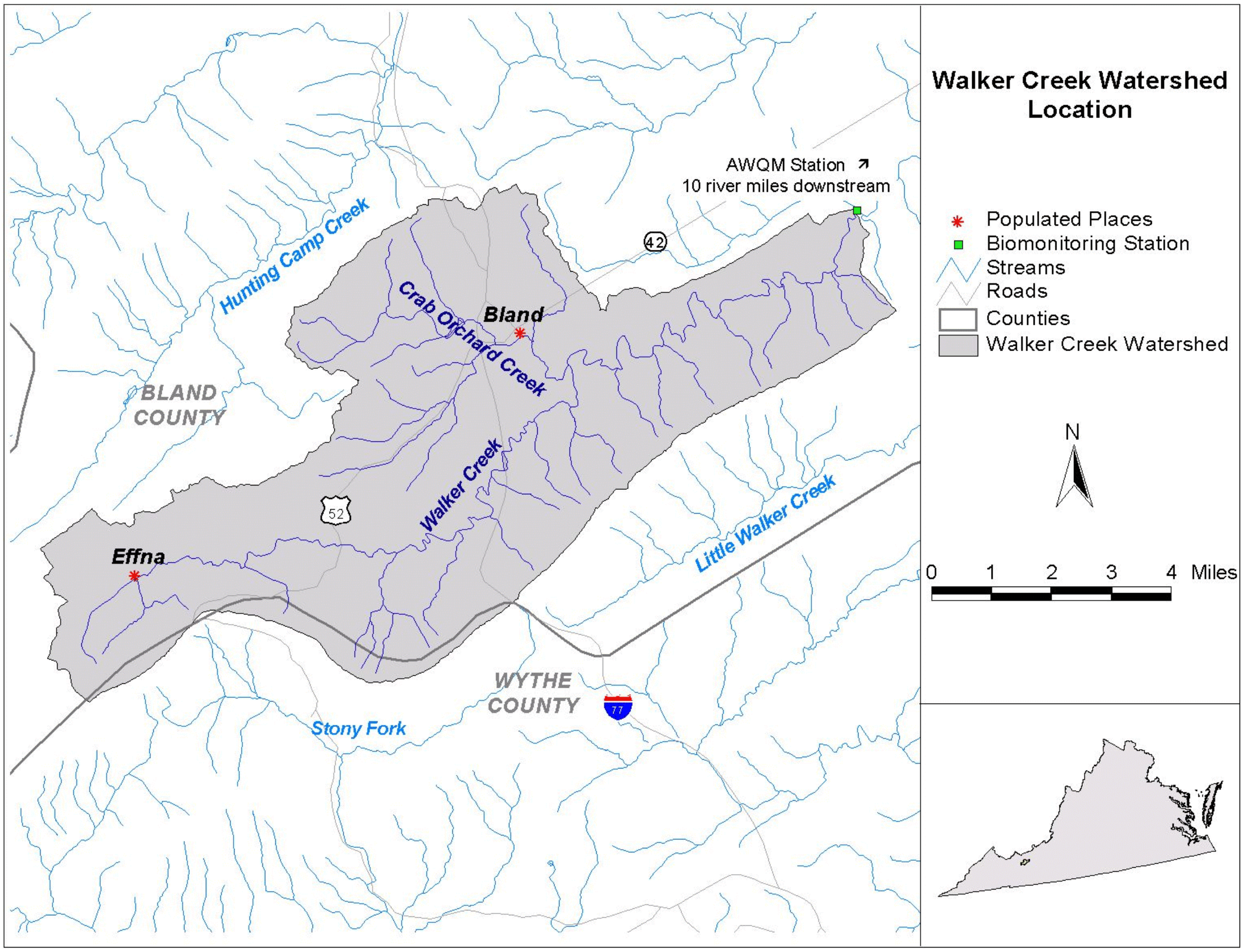

Figure 2.5 Walker Creek watershed location and monitoring stations

SECTION 3

STRESSOR IDENTIFICATION

3.1 Stressor Identification Process

Biological assessments are useful in detecting impairment, but they do not necessarily identify the cause(s) of impairment. EPA developed the *Stressor Identification: Technical Guidance Document* to assist water resource managers in identifying stressors or combinations of stressors that cause biological impairment (Cormier et al. 2000). Elements of the stressor identification process were used to evaluate and identify the primary stressors of the benthic communities in Cedar Creek, Hall/Byers Creek, and Hutton Creek. Watershed and water quality data from these streams, reference watershed data, and field observations were used to help identify candidate causes.

3.2 Candidate Causes

Based on information provided by VADEQ and watershed data collected at the beginning of the TMDL study, it was hypothesized that sedimentation from non-point source inputs was responsible for the listed benthic impairments. A field visit to each TMDL watershed was conducted by Tetra Tech and VADEQ personnel on October 9, 2002 to gather information on stream and watershed characteristics for stressor identification and modeling studies. Field observations confirmed the likelihood that sedimentation was primarily responsible for negative impacts to the benthic macroinvertebrate community in these streams. Potential stressors and their relationships to benthic community condition are discussed below.

3.2.1 Low Dissolved Oxygen

Organic enrichment can cause low dissolved oxygen (DO) levels which stress benthic organisms. In general, high nitrogen and phosphorus levels can lead to increased production of algae and macrophytes, which can result in the depletion of oxygen in the water column through metabolic respiration. In addition, at higher water temperatures the concentration of dissolved oxygen is lower because the solubility of oxygen (and other gases) decreases with increasing temperature. Higher water temperatures can be caused by the loss of shading, higher evaporation rates, reduced stream flow, and other factors.

Aquatic organisms, including benthic macroinvertebrates, are dependent upon an adequate concentration of dissolved oxygen. Less tolerant organisms generally cannot survive or are outcompeted by more tolerant organisms under low dissolved oxygen conditions. This process reduces diversity and alters community composition from a natural state. Aquatic insects and other benthic organisms serve as food items for fishes, therefore, alterations in the benthic community can impact fish feeding ecology (Hayward and Margraf 1987; Leach et al. 1977).

3.2.2 Sedimentation

Excessive sedimentation from anthropogenic sources is a common problem that can impact the stream biota in a number of ways. Deposited sediments reduce habitat complexity by filling pools, critical riffle areas, and the interstitial spaces used by aquatic invertebrates. Substrate size is a particularly important factor that influences the abundance and distribution of aquatic insects. Sediment particles at high concentrations can directly affect aquatic invertebrates by clogging gill surfaces and lowering respiration capacity. Suspended sediment also increases turbidity in the water column which can affect the feeding efficiency of visual predators and filter feeders. In addition, pollutants, such as phosphorus, adsorb to sediment particles and are transported to streams through erosion processes.

3.2.3 Habitat Alteration

The relative lack of riparian vegetation along sections of these streams was considered to be a potential factor affecting the benthic community. Minimal riparian vegetation was observed in specific areas during the TMDL field visit. In these watersheds, riparian areas are often used to grow crops and as pasture for livestock. Riparian areas perform many functions that are critical to the ecology of the streams that they border (Figure 3.1). Functional values include:

- Flood detention
- Plant roots stabilize banks and prevent erosion
- Nutrient cycling
- Wildlife habitat
- Canopy vegetation provides shading (decreases water temperature and increases baseflow through lower evaporation rates)

3.2.4 Toxic Pollutants

Toxic pollutants in the water column and sediment can result in acute and chronic effects on aquatic organisms. Increased mortality rates, reduced growth and fecundity, respiratory problems, tumors, deformities, and other consequences have been documented in toxicity studies of aquatic organisms. Degraded water quality conditions and other environmental stressors can lead to higher rates of incidence of these problems.

3.3 Monitoring Stations

VADEQ monitors water quality on Cedar Creek, Hall/Byers Creek, and Hutton Creek on a monthly basis as part of the Ambient Water Quality Monitoring (AWQM) program. Benthic community data are also collected at biomonitoring stations. Station locations are listed in Table 3.1. The nearest active USGS stream flow gauge is USGS 03475000, located on the Middle Fork Holston River near Meadowview.

Table 3.1 Monitoring stations on TMDL streams

Station Type	Station Number	Stream and Location
AWQM	6CBYS000.23	Hall/Byers Creek
	6CCED000.14	Cedar Creek
	6CHTO000.24	Hutton Creek
Biomonitoring	6CBYS000.08	Hall/Byers Creek
	6CCED000.04	Cedar Creek
	6CHTO000.07	Hutton Creek

3.4 Water Quality Summary

3.4.1 Ambient Water Quality Monitoring (AWQM) Summary

Cedar Creek, Hall/Byers Creek, and Hutton Creek are classified as Mountainous Zone Waters (Class IV) in Virginia Water Quality Standards (9 VAC 25-260-50). Numeric criteria for dissolved oxygen (DO), pH, and maximum temperature for Class IV waters are shown in Table 3.2.

Table 3.2 Virginia numeric criteria for Class IV waters

Dissolved Oxygen (mg/L)			
Minimum	Daily Average	pH (standard units)	Maximum Temperature (ºC)
4.0	5.0	6.0 - 9.0	31

Water quality monitoring data were summarized to help determine general water quality conditions for each impaired stream. Tables 3.3 through 3.5 list the available parameters for each station, provides basic summary statistics, and lists the period of record and number of observations.

Table 3.3 General Water Quality Data for Hall/Byers Creek - 6CBYS000.23

PERIOD OF RECORD 10/25/2000 - 11/05/2002	MIN	MAX	AVERAGE	# OBS
Temp Celcius	2.51	18.90	12.44	41
Do Probe	8.32	13.42	10.19	41
Field Ph	7.57	8.41	8.00	41
ALKALINITY (MG as CA CO3)	1.00	221.00	188.24	15
AMMONIA, TOTAL	0.04	0.18	0.05	40
BOD5 (MG/L)	2.00	2.00	2.00	7
DISSOLVED SOLIDS, TOTAL (MG/L)	5.00	339.00	276.44	14
FECAL COLIFORM (MFM-FCBR/100 ML)	100.00	8000.00	1530.77	37
FIXED SOLIDS (MG/L)	5.00	302.00	253.51	39
FIXED SUSPENDED SOLIDS (MG/L)	3.00	77.00	14.78	39
HARDNESS, EDTA (MG/L AS CACO3)	5.00	273.00	220.44	39
LAB SPECIFIC CONDUCTANCE	2.10	568.00	494.49	39
NITRATE, TOTAL (MG/L AS N)	0.04	4.26	2.22	40
NITRITE, TOTAL (MG/L AS N)	0.01	0.10	0.02	40
NITROGEN, TOTAL KJELDAHL (MG/L AS N)	0.10	1.70	0.35	41
PH, LAB (SU)	5.55	6.96	6.45	15
TOTAL OTHROPHOSPHATE (MG/L AS P)	0.02	0.26	0.09	40
PHOSPHORUS, TOTAL (MG/L AS P)	0.01	0.45	0.12	41
SULPHATE, TOTAL (MG/L AS SO4)	5.00	47.00	32.17	15
TOTAL SOLIDS, (MG/L)	5.00	373.00	318.68	39
TOTAL SUSPENDED SOLIDS (MG/L)	3.00	87.00	18.17	39
TURBIDITY FTU - HACH TURBIDIMETER	0.20	66.60	12.81	39

Table 3.4 General Water Quality Data for Cedar Creek - 6CCED000.14

PERIOD OF RECORD 10/25/2000 - 11/05/2002	MIN	MAX	AVERAGE	# OBS
Temp Celcius	0.6	20.7	12.8	41.0
Do Probe	8.2	13.7	10.3	41.0
Field Ph	6.9	8.6	8.1	41.0
ALKALINITY (MG/L AS CA CO3)	226.0	244.0	233.6	15.0
AMMONIA, TOTAL (MG/L AS N)	0.0	0.1	0.0	39.0
BOD5 (MG/L)	2.0	2.0	2.0	7.0
DISSOLVED SOLIDS, TOTAL (MG/L)	271.0	310.0	286.6	14.0
FECAL COLIFORM (MFM-FCBR/100 ML)	100.0	8000.0	1556.6	38.0
FIXED SOLIDS (MG/L)	17.0	291.0	242.3	39.0
FIXED SUSPENDED SOLIDS (MG/L)	3.0	42.0	13.1	39.0
HARDNESS, EDTA (MG/L AS CACO3)	18.5	281.0	228.9	38.0
LAB SPECIFIC CONDUCTANCE	47.7	557.0	490.4	39.0
NITRATE, TOTAL (MG/L AS N)	1.7	5.7	2.7	39.0
NITRITE, TOTAL (MG/L AS N)	0.0	0.1	0.0	39.0
NITROGEN, TOTAL KJELDAHL (MG/L AS N)	0.1	1.3	0.4	40.0
PH, LAB (SU)	6.3	7.1	6.7	15.0
TOTAL OTHROPHOSPHATE (MG/L AS P)	0.0	0.1	0.0	39.0
PHOSPHORUS, TOTAL (MG/L AS P)	0.0	0.1	0.1	40.0
SULPHATE, TOTAL (MG/L AS SO4)	6.4	9.6	7.7	15.0
TOTAL SOLIDS, (MG/L)	36.0	368.0	307.8	39.0
TOTAL SUSPENDED SOLIDS (MG/L)	3.0	53.0	17.2	39.0
TURBIDITY FTU - HACH TURBIDIMETER	1.2	26.4	9.9	39.0

Table 3.5 General Water Quality Data for Hutton Creek - 6CHTO000.24

Period of Record 09/13/2000 - 11/05/2002	MIN	MAX	AVERAGE	# OBS.
Temp Celcius	6.80	19.50	13.47	41.00
Do Probe	7.92	13.88	10.35	41.00
Field Ph	6.73	8.44	7.89	41.00
ALKALINITY (MG/L AS CA CO3)	196.00	235.00	220.56	15.00
AMMONIA, TOTAL (MG/L AS N)	0.04	0.35	0.05	39.00
BOD5 (MG/L)	2.00	2.00	2.00	7.00
DISSOLVED SOLIDS, TOTAL (MG/L)	272.00	315.00	291.67	14.00
FECAL COLIFORM (MFM-FCBR/100 ML)	100.00	8000.00	3294.74	37.00
FIXED SOLIDS (MG/L)	5.00	321.00	246.18	39.00
FIXED SUSPENDED SOLIDS (MG/L)	3.00	150.00	15.83	39.00
HARDNESS, EDTA (MG/L AS CACO3)	6.30	271.00	213.65	38.00
LAB SPECIFIC CONDUCTANCE	1.90	575.00	497.22	39.00
NITRATE, TOTAL (MG/L AS N)	0.04	3.50	1.91	39.00
NITRITE, TOTAL (MG/L AS N)	0.01	0.09	0.02	39.00
NITROGEN, TOTAL KJELDAHL (MG/L AS N)	0.10	2.80	0.35	40.00
PH, LAB (SU)	6.17	6.99	6.52	15.00
TOTAL OTHROPHOSPHATE (MG/L AS P)	0.02	0.35	0.04	39.00
PHOSPHORUS, TOTAL (MG/L AS P)	0.01	1.02	0.08	40.00
SULPHATE, TOTAL (MG/L AS SO4)	15.50	28.00	21.22	15.00
TOTAL SOLIDS, (MG/L)	5.00	442.00	318.15	39.00
TOTAL SUSPENDED SOLIDS (MG/L)	3.00	192.00	19.70	39.00
TURBIDITY FTU - HACH TURBIDIMETER	0.19	181.00	14.54	39.00

3.4.2 Diel DO Analysis

To investigate the potential for low DO concentrations, VADEQ recorded the DO concentration at each AWQM station in the early morning hours on August 29, 2002 (Table 3.6). Primary producers (algae and macrophytes) produce oxygen during the day through photosynthesis and use oxygen during the night through respiration. This diel photosynthesis/ respiration cycle results in higher DO concentrations during the day and lower DO concentrations at night.

VADEQ collected these data during summer, low-flow conditions. Low dissolved oxygen conditions, which stress the benthic macroinvertebrate community, typically occur in the late summer/early fall when stream temperatures are their warmest and streamflow is lower. These conditions provide information on dissolved oxygen levels that may occur during these critical periods when algal blooms can cause hypoxic or anoxic conditions. DO concentrations during this sampling event were well above water quality standards.

Table 3.6 DEQ summer DO study (sampling date: 8/29/02)

Station	Time	Temp (Celsius)	PH	DO (mg/L)
6CBYS000.23	5:45	17.2	7.74	7.93
6CCED000.14	5:55	17.8	7.87	8.17
6CHTO000.24	5:30	15.1	7.53	7.97

3.5 Toxic Pollutants - Surface Water

Virginia Water Quality Standards list acute and chronic criteria for surface waters (9 VAC 25-260-140). These numeric criteria were developed for metals, pesticides, and other toxic chemicals which can cause acute and chronic toxicity effects on aquatic life and human health. Available water quality data were compared to these criteria to determine possible effects on aquatic life. Ammonia data were collected during monthly ambient monitoring runs (see Tables 3.3 through 3.5 and Section 3.8). No exceedances of listed parameters were identified.

3.6 Toxic Pollutants - Sediment

Sediment criteria for toxic pollutants are not specifically listed in Virginia Water Quality Standards. Sediment data were assessed using NOAA Effects Range-Median (ER-M) screening values. No exceedances were noted for sampled parameters.

3.7 EPA Toxicity Testing

Toxicity tests were conducted by EPA Region 3 to determine possible toxic effects on aquatic organisms in these streams (USEPA 2003b). Water (grab) samples were collected by VADEQ at the AWQM station on each stream. These samples were shipped to the EPA Region 3 lab in Wheeling, West Virginia for processing. The survival/growth of fathead minnows (*Pimephales promelas*) and the survival/reproduction of *Ceriodaphnia dubia* were measured using standard toxicity testing methods.

Acute effects were not observed for either test organism. Subchronic effects on minnow growth were noted for Byers Creek and Cedar Creek samples, however, these results were not considered to be biologically significant due to the minimal variation in the control sample results.

3.8 Reference Data Comparisons

Water quality data comparisons between the impaired streams and Walker Creek were used to help identify the causes of biological impairment. In general, stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to meet designated uses; therefore, comparative analyses of watershed and water quality data were used in stressor identification.

Data range plots were used to compare individual water quality parameters. This type of plot displays the median value and the non-outlier minimum/maximum range of the dataset for each parameter.

Dissolved Oxygen

All streams had acceptable DO conditions based on the AWQM data collected at each monitoring station. The minimum DO recorded at each station was well above the 5.0 mg/L daily average criterion. Figure 3.1 shows the plot of DO concentrations for the period of record for the AWQM station on each impaired stream and the reference stream, Walker Creek. These data support the results of the diel DO analysis referenced in Section 3.4.2.

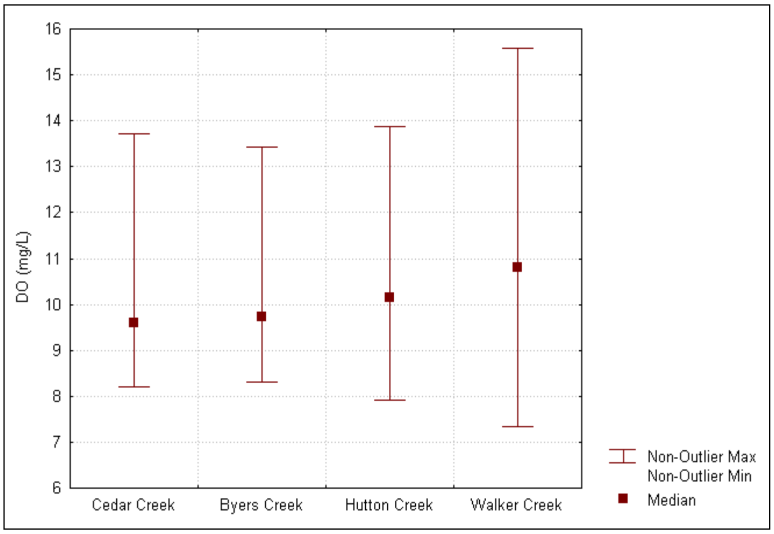

Figure 3.1 Comparison of AWQM dissolved oxygen data

Phosphorus

Phosphorus (P) is generally present in waters and wastewaters in different species of soluble (dissolved) and insoluble (particulate or suspended) phosphates, including inorganic (ortho- and condensed) phosphates and organic phosphates. Orthophosphates (soluble) may be associated with detergents and fertilizers and can be found in streams receiving fertilizer-laden runoff. Organic forms of phosphate are associated with wastes containing high organic loadings such as domestic sewage and agricultural wastewaters. Figure 3.2 shows the range of values for Total Phosphorus observations for impaired and reference streams.

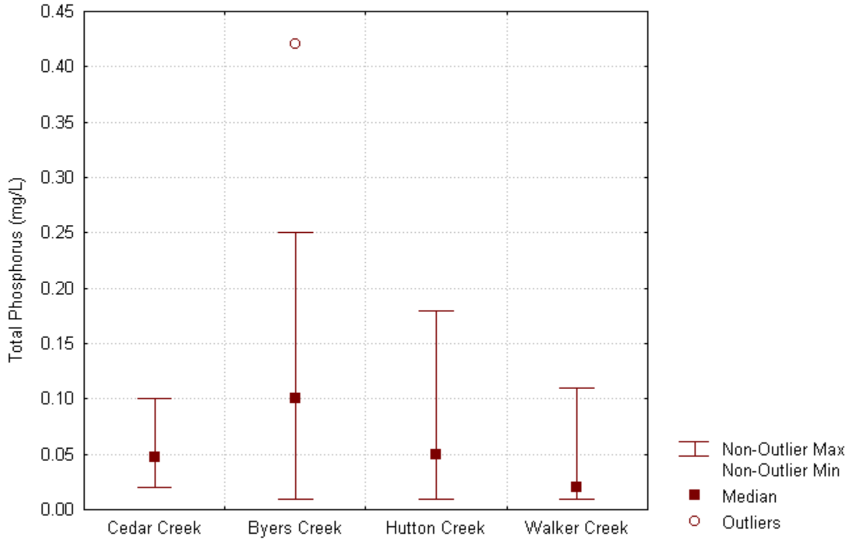

Figure 3.2 Comparison of AWQM total phosphorus data

Median total phosphorus values in impaired streams are higher than in Walker Creek. With the exception of Cedar Creek, the maximum phosphorus levels in the impaired streams are also higher than the maximum phosphorus levels in Walker Creek. Hall/Byers Creek had the highest levels of orthophosphorus, while all of the impaired streams exhibit both higher average and maximum orthophosphate levels than does the reference stream (Figure 3.3). Although the total phosphorus and organic phosphorus data are elevated in the impaired streams as compared to Walker Creek, DO concentrations appear to be adequate to support a healthy benthic community, therefore, phosphorus reductions do not appear to be necessary.

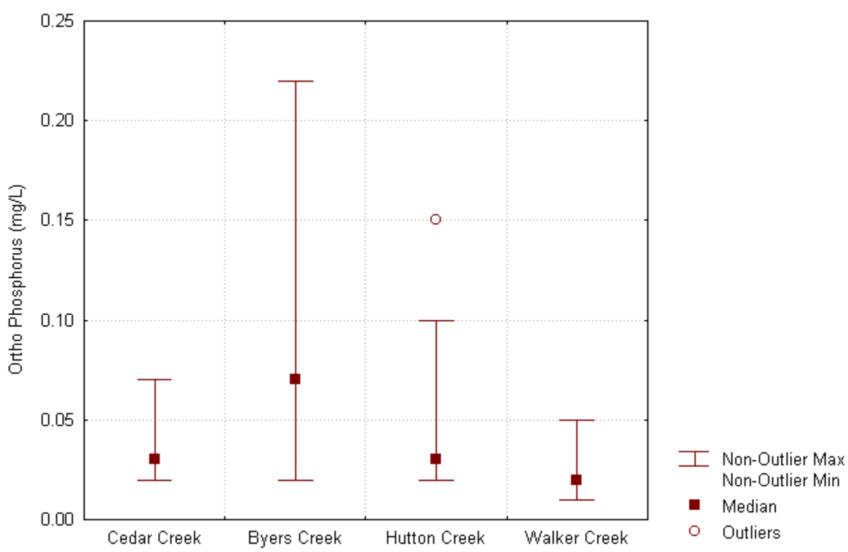

Figure 3.3 Comparison of AWQM orthophosphorus data

Nitrogen

Compounds containing nitrogen such as nitrates, nitrites, and ammonia, act as nutrients. Major sources of nitrogen include municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes, runoff from fertilized agricultural field and lawns, and discharges from car exhausts. Figures 3.4 and 3.5 show the range of observed nitrate and nitrite levels measured in the impaired streams and Walker Creek, respectively. Phosphorus is the limiting nutrient for algal growth in these streams based on N/P ratios.

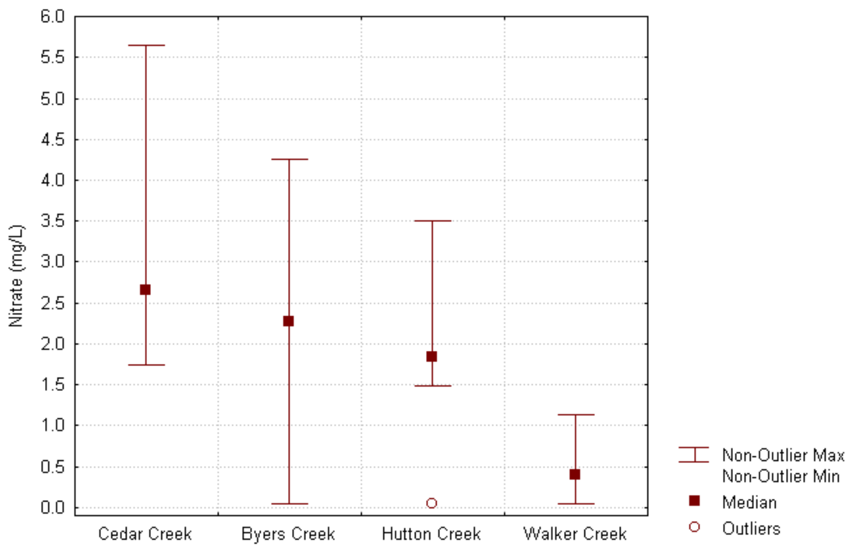

Figure 3.4 Comparison of AWQM nitrate data

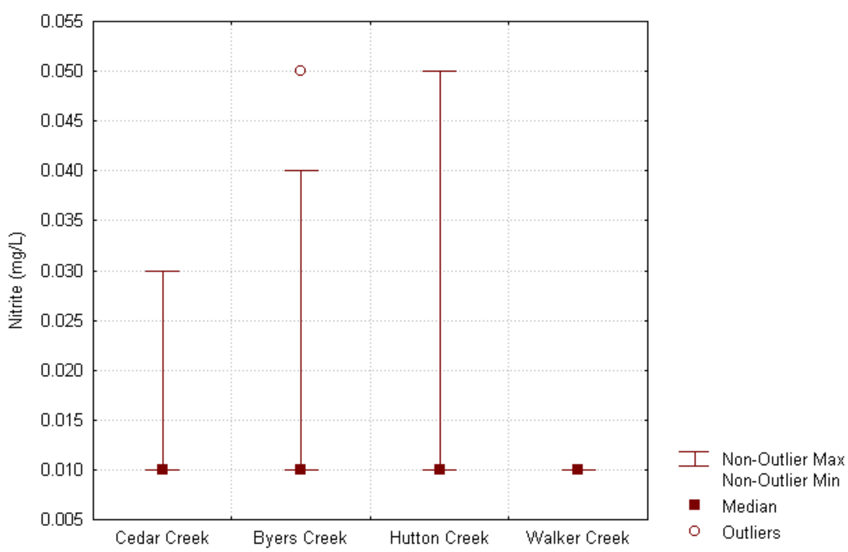

Figure 3.5 Comparison of AWQM nitrite data

Ammonia is a critical component of the nitrogen cycle. At high concentrations, ammonia is toxic to aquatic life, depending on instream pH and temperature levels. In general, higher temperature and pH levels increase the toxicity of ammonia. Virginia Water Quality Standards (9 VAC 25-260-140) list acute and chronic criteria for ammonia. Figure 3.6 shows total ammonia (NH3+NH4) values for impaired and reference streams. Although median and maximum ammonia values for Cedar Creek and Hutton Creek were higher than in the reference stream, there were no exceedances of the ammonia criteria based on temperature and pH values recorded during sampling.

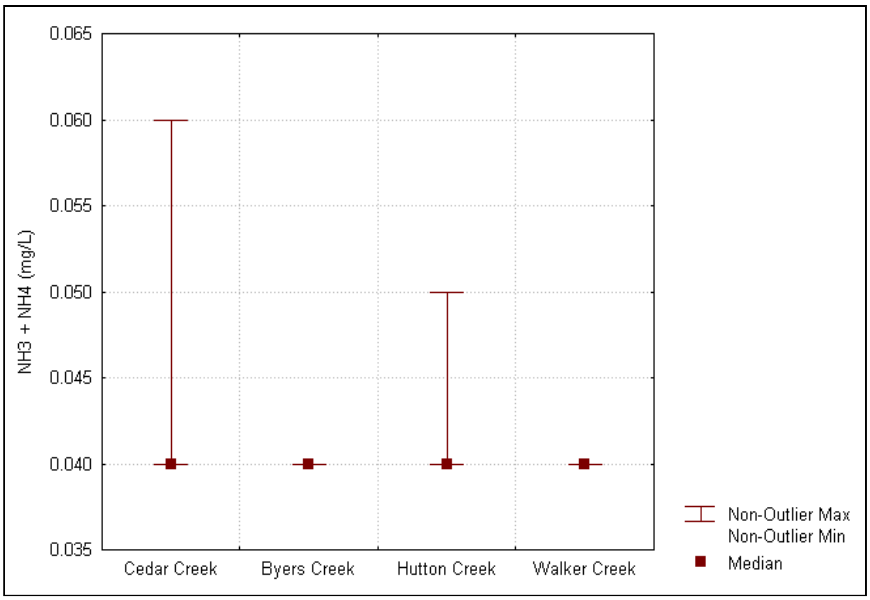

Figure 3.6 Comparison of AWQM ammonia data

Sedimentation Indicators

Excessive sedimentation can cause impacts to the benthic community through habitat alteration, smothering, filling of interstitial spaces, and other effects. Total suspended solids (TSS), turbidity, and Rapid Bioassessment Protocol (RBP) habitat data were used to examine possible sedimentation impacts on the benthic macroinvertebrate community. A similar trend among sites is exhibited for TSS and turbidity data (Figures 3.7 and 3.8). Median and maximum TSS values were higher in the impaired streams as compared to Walker Creek. Median turbidity values were also higher in the impaired streams and maximum values were higher in Hall/Byers Creek and Hutton Creek. These data coupled with habitat observations by VADEQ personnel indicate the likelihood of sedimentation effects on the benthic community (Table 3.7).

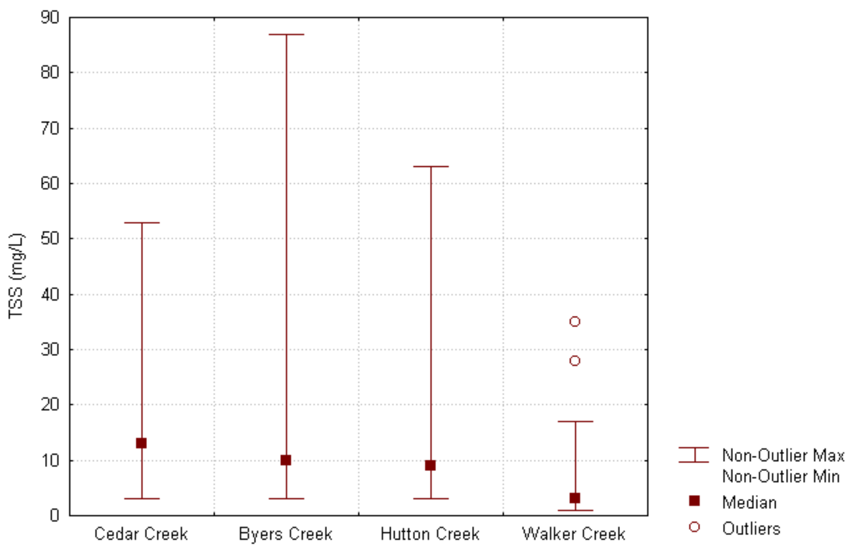

Figure 3.7 Comparison of AWQM TSS data

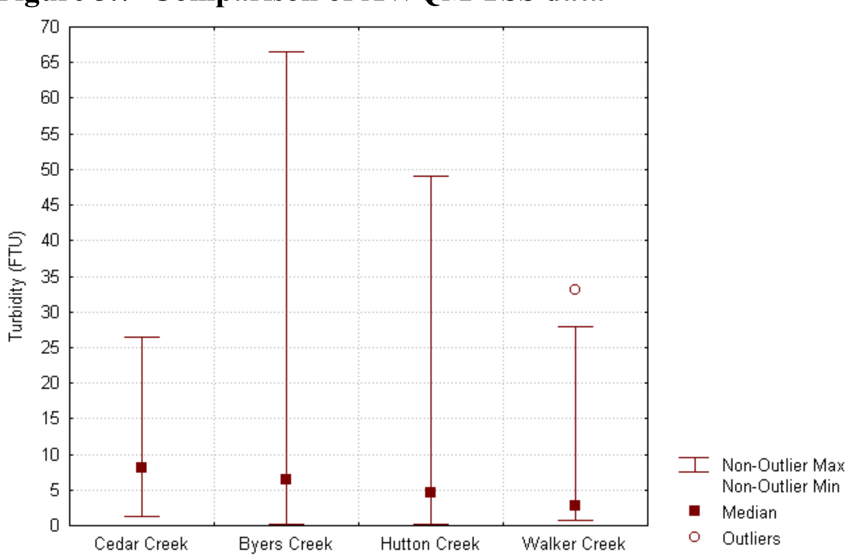

Figure 3.8 Comparison of AWQM turbidity data

Table 3.7 RBP habitat data - sedimentation parameters (scores were rated by observation using a 0-20 scale, higher score indicates better habitat conditions)

Station	Embeddedness	Epifaunal Substrate	Sediment Deposition
6CCED000.04 (Cedar Creek)	7	7	6
6CBYS000.08 (Hall/Byers Creek)	8	7	6
6CHTO000.07 (Hutton Creek)	9	15	7
9-WLK050.85 (Walker Creek, avg.)	11	14	11

3.9 Stressors and Selected Endpoints

Sedimentation

Excessive sedimentation is considered to be the primary cause of the listed benthic impairments in both streams. This determination is based on field observations and ambient water quality monitoring data that indicate sedimentation impacts. Agricultural and urban runoff, stream bank de-stabilization, the loss of riparian buffers, and other processes have resulted in sedimentation impacts to the benthic community in these streams. Sediment TMDLs and associated load reductions were, therefore, developed for Cedar Creek, Hall/Byers Creek, and Hutton Creek. As described in Section 6, the numeric endpoint for sediment loading was based on the average annual load in tons/year of the reference watershed.

SECTION 4

SOURCE ASSESSMENT - SEDIMENT

Point and nonpoint sources of sediment were assessed in TMDL development. The source assessment was used as the basis of model development and analysis of TMDL allocation options. A variety of information was used to characterize sources in impaired and reference watersheds including: agricultural and land use information provided by VADCR and other sources, water quality monitoring and point source data provided by VADEQ, soils data provided by the Holston River SWCD and NRCS, past TMDL studies, literature sources, and other information. Procedures and assumptions used in estimating sediment and phosphorus sources in the impaired watersheds are described in the following sections. Similar procedures were used to derive the required input data for reference watersheds, although the specific data products used varied for each watershed. Whenever possible, data development and source characterization was accomplished using locally-derived information.

4.1 Assessment of Nonpoint Sources

Erosion of the land results in the transport of sediment to receiving waters through various processes. Factors that influence erosion include characteristics of the soil, vegetative cover, topography, and climate. Nonpoint sources, such as agricultural land uses and construction areas, are large contributors of sediment because the percentage of vegetative cover is typically lower. Urban areas can also contribute quantities of sediment to surface waters through the build-up and eventual washoff of soil particles, dust, debris, and other accumulated materials. Pervious urban areas, such as lawns and other green spaces contribute sediment in the same fashion as low-intensity pasture areas or other similar land uses. In addition, streambank erosion and scouring processes can result in the transport of additional sediment loads.

4.1.1 Agricultural Land

Agricultural land was identified as a major source of sediment in the impaired watersheds. Agricultural runoff can contribute increased pollutant loads when farm management practices allow soils rich in nutrients from fertilizers or animal waste to be washed into the stream, increasing in-stream sediment and phosphorus levels. The erosion potential of cropland and over-grazed pasture land is particularly high due to the lack of year-round vegetative cover. The use of cover crops and other management practices have been shown to reduce the transport of pollutant loads from agricultural lands. Streambank erosion is also a potential source of sediment in agricultural watersheds, due to the removal of riparian vegetation and other factors. Bank stabilization measures and riparian plantings can significantly reduce streambank erosion.

VADCR land use types in the impaired watersheds are shown in Table 2.1. Consolidated land uses are shown in Table 2.2.

4.1.2 Forest Land

Agricultural and urban development in these watersheds has replaced some mature forest areas, especially along streams and at lower elevations. The remaining forest lands, generally, occupy higher elevations and agriculturally unproductive areas. The sediment yield from undisturbed forest lands, especially during the growing season, is low due to the amount of dense vegetative cover which stabilizes soils and reduces rainfall impact. Clear-cut and other harvested areas have a higher erosion potential.

4.1.3 Urban Areas

Urban land uses represented in the VADCR land use coverage include commercial, industrial, transportation, and residential areas. Urban land uses consist of pervious and impervious areas. Stormwater runoff from impervious areas, such as paved roads and parking lots, contribute pollutants that accumulate on these surfaces directly to receiving waters without being filtered by soil or vegetation. Sediment deposits in impervious areas originate from vehicle exhaust, industrial and commercial activities, outdoor storage piles, and other sources. In addition, stormwater runoff can cause streambank erosion and bottom scouring through high flow volumes, resulting in increased sedimentation and other habitat impacts.

The primary urban sources of sediment are construction sites and other pervious lands. Construction sites have high erosion rates due to the removal of vegetation and top soil. Typical erosion rates for construction sites are 35 to 45 tons per acre per year as compared to 1 to 10 tons per acre per year for cropland. Residential lawns and other green spaces contribute sediment in the same fashion as low-intensity pasture areas or other similar land uses.

Urban land use areas were separated into pervious and impervious fractions based on the estimated percent impervious surface of each urban land use category. Field observations and literature values were used to determine the effective percent imperviousness of urban land uses (Table 4.1). Construction sites, quarries, and other bare soil areas are represented as “Disturbed Area” in the VADCR land use coverage.

Table 4.1 Percent imperviousness of urban land uses in TMDL watersheds

Urban land uses	Percent impervious
High Intensity Residential	40%
Low Intensity Residential	20%

4.2 Assessment of Point Sources

Point sources can contribute sediment loads to surface waters through effluent discharges. These facilities are permitted through the Virginia Pollutant Discharge Elimination System (VPDES) program that is managed by VADEQ. VPDES individual permits are issued to facilities that must comply with permit conditions that include specific discharge limits and requirements. There are four point sources of sediment in the impaired watersheds.(Table 4.2). Two of the sediment point sources are located in the Cedar Creek watershed, one is located in the Hall/Byers Creek watershed, and one is located in the Hutton Creek watershed. Meadowview Elementary School (VA0030589) and Dillow's Shop and Wash (VA0071366) are located the Cedar Creek watershed, each have a permitted design flow of 0.016 mgd and 0.04 mgd respectively. The Emory-Meadowview WWTP (VA0087378) is located in the Hall/Byers Creek watershed and has a permitted flow of 0.630 mgd. A permitted TSS concentration of 30 mg/L was taken for all the point sources.

General permits are granted for smaller facilities, such as domestic sewage discharges, that must comply with a standard set of permit conditions, depending on facility type. Currently, there is one VPDES domestic sewage discharge general permit in the Hutton Creek watershed. The facility discharges less than 1,000 gallons per day (gpd). The annual sediment load contributed by each facility was calculated based on the permitted TSS concentration of 30 mg/L and the maximum allowable flow (1,000 gpd). The annual sediment and phosphorus loads contributed by each facility were calculated using the information listed in Tables 4.3 .

Table 4.2. VPDES point sources and TSS loads in the impaired watersheds

Stream	Facility Name	VPDES Permit No.	Discharge Type	Design Flow (MGD)	Permitted Concentration (mg/L)	TSS Load (pounds/year)
Cedar Creek	Meadowview Elementary School	VA0030589	Municipal	0.016	30	1,461.17
	Dillow's Shop and Wash	VA0071366	Municipal/Industrial	0.004	30	328.76
Hall/Byers Creek	Emory-Meadowview WWTP	VA0087378	Municipal	0.630	30	57533.49
Hutton Creek	Smith Residence, SFH STP	VAG400181	Single Family House	<.001	30	91.32

SECTION 5

WATERSHED MODELING

5.1 Overall Technical Approach

As discussed in Section 2.1, a reference watershed approach was used in this study to develop TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek. A watershed model was used to simulate the sediment loads from potential sources in impaired and reference watersheds. The watershed model used in this study was the Generalized Watershed Loading Functions (GWLF) model (Haith and Shoemaker 1987). GWLF modeling was accomplished using the BasinSim 1.0 watershed simulation program, which is a windows-based modeling system that facilitates the development of model input data and provides additional functionality (Dai et al. 2000). Numeric endpoints were based on the unit-area loading rates that were calculated for the reference watershed. TMDLs were then developed for each impaired stream segment based on these endpoints and the results from load allocation scenarios.

5.2 Watershed Model

TMDLs were developed using BasinSim 1.0 and the GWLF model. The GWLF model, which was originally developed by Cornell University (Haith and Shoemaker 1987, Haith et al. 1992), provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. GWLF is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance totals that are summed to give monthly values.

GWLF is an aggregate distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous with respect to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as for a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss/erosion (K), the length/slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Point source discharges also can contribute to loads to the stream Evapotranspiration is determined using daily weather data and a cover factor dependent on land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be found in the original GWLF paper (Haith and Shoemaker 1987) and GWLF User's Manual (Haith et al. 1992).

For execution, the model requires three separate input files containing transport, nutrient, and weather-related data. The transport file (TRANSPRT.DAT) defines the necessary parameters for each source area to be considered (e.g., area size, curve number) as well as global parameters (e.g., initial storage, sediment delivery ratio) that apply to all source areas. The nutrient file (NUTRIENT.DAT) specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations). The nutrient file is necessary for the model to run but is not used in any of the calculations. The weather file (WEATHER .DAT) contains daily average temperature and total precipitation values for each year simulated.

5.3 Model Setup

Watershed data needed to run the GWLF model in BasinSim 1.0 were generated using GIS spatial coverages, water quality monitoring and streamflow data, local weather data, literature values, and other information. Watershed boundaries for Cedar Creek, Hall/Byers Creek, and Hutton Creek are the same as those used in the previous bacteria TMDL study. Reference watersheds were delineated using USGS 7.5 minute digital topographic maps (24K DRG - Digital Raster Graphics). The reference watershed outlet is located at the VADEQ biomonitoring station on Walker Creek. To equate target and reference watershed areas for TMDL development, the total area for the reference watershed was reduced to be equal to the area of its paired target watershed, after hydrology calibration. To accomplish this, land use areas (in the reference watershed) were proportionally reduced based on the percent land use distribution. As a result, the total watershed area for Walker Creek was reduced to be equal to the Cedar Creek, Hall/Byers Creek, and Hutton Creek watershed areas.

Local rainfall and temperature data were used to simulate flow conditions in modeled watersheds. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations. Weather stations that correspond with the modeled watersheds are shown in Table 5.1. The period of record selected for model calibration runs (April 1, 1980 through March 31, 2000 for the Walker Creek watershed model and April 1, 1988 through March 31, 1989 for the Cedar Creek, Hall/Byers Creek, and Hutton Creek watershed model) was based on the availability of recent weather data and corresponding streamflow records. Even though weather data was available for the 20 year period the calibration period at the three impaired watersheds was governed by the availablility of the streamflow records. The weather data collected at the NCDC station of Wytheville (precipitation data) and Bristol (temperature data) were used to construct the weather file used in all four watershed simulations.

Table 5.1 Weather stations used in GWLF models

Watershed	Weather Station	Data Type	Data Period
Walker Creek, Cedar Creek, Hall/Byers Creek, and Hutton Creek	Wytheville	Daily Precipitation	4/1/80 - 3/31/00
	Bristol	Daily Temperature	4/1/80 - 3/31/00

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. The USGS station located on Walker Creek was used to calibrate the reference watershed. The three creeks were calibrated using the USGS streamflow gaging station at Middle Fork Holston River. Table 5.2 lists the USGS gaging stations along with their period of record for the appropriate watersheds.

Table 5.2 USGS gaging stations used in modeling studies

Modeled Watershed	USGS station number	USGS gage location	Data Period
Walker Creek	03173000	Walker Creek at Bane, VA	4/1/1938 to 9/30/2002
Cedar Creek, Hall/Byers Creek, and Holmans Creek	03473500	M F Holston River at Groseclose, VA	1/10/1987 to 9/30/1989

5.4 Explanation of Important Model Parameters

In the GWLF model, the nonpoint source load calculation is affected by terrain conditions, such as the amount of agricultural land, land slope, soil erodibility, farming practices used in the area, and by background concentrations of nutrients (nitrogen and phosphorus) in soil and groundwater. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized as follows:

Areal extent of different land use/cover categories: VADCR and MRLC land use coverages were used to calculate the area of each land use category in impaired and reference watersheds, respectively.

Curve number: This parameter determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type and is calculated directly using digital land use and soils coverages. Soils data were obtained from the Holston River SWCD and NRCS. This information is presented in the Washington County soil survey. The State Soil Geographic (STATSGO) database for Virginia, developed by NRCS, was the source of soils data for the Walker Creek watershed.

K factor: This factor relates to inherent soil erodibility, and it affects the amount of soil erosion taking place on a given unit of land. The K factor and other Universal Soils Loss Equation (USLE) parameters were downloaded from the NRCS Natural Resources Inventory (NRI) database (1992). Average values for specific crops/land uses in each watershed county were used (Bland and Washington counties). The predominant crop grown in these watersheds is corn; therefore, cropland values were based on data collected in corn crops.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, this factor is largely controlled by the crops grown and the cultivation practices used. Values range from 0 to 1.0, with larger values indicating a higher potential for erosion.

P factor: This factor is directly related to the conservation practices used in agricultural areas. Values range from 0 to 1.0, with larger values indicating a lower potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This parameter relates to the amount of water that can be stored in the soil and affects runoff and infiltration.

Other less important factors that can affect sediment loads in a watershed also are included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF User's Manual (Haith et al. 1992). Pages 15 through 41 of the manual provide specific details that describe equations and typical parameter values used in the model.

5.5 Hydrology Calibration

Using the input files created in the BasinSim 1.0, GWLF predicted overall water balances in impaired and reference watersheds.As discussed in Section 5.3, the modeling period is determined based on the availability of weather and flow data that were collected during the same time period. For all four watersheds (Walker Creek, Cedar Creek, Hall/Byers Creek, and Hutton Creek) weather data obtained from the NCDC meteorological stations located at Wytheville and Bristol were used to model the watersheds. However, the calibration period was governed by the availablility of the USGS gaging data. The Walker Creek watershed (reference watershed) was calibrated for an extended period of twenty years from 4/1980 to 3/2000 using the Walker Creek streamflow gage data. The Hoston River USGS gage was used in the calibration of the three impaired watersheds. There is limited flow data at the Holston River USGS gage, and most of the data in 1987 from 1/10/1987 to 12/8/1987 is estimated flow as reported by USGS. Due to this data constraint, only one year calibration from 4/1988 to 3/1989 was performed on the three creeks. Although both the streamflow gages were in close proximity of the reference and the three impaired creeks, the gages did not coincide with the pour point of the watershed. Hence, the streamflow measurements were normalized by area to facilitate calibration. Calibration statistics are presented in Table 5.3. In general, an R^2 value greater than 0.7 indicates a strong, positive correlation between simulated and observed data. These results indicate a good correlation between simulated and observed results for these watersheds. A total flow volume error percentage of less than 10 percent was achieved, except for Walker Creek. Some of the volume error estimates could be attributed to the period between January 1995 to early June of 1995 where no rainfall was recorded at the weather stations used in the model to produce a corresponding response in the model that was similar to that seen in the gaging station. In general the seasonal trends and peaks are captured reasonably well for the twenty year period in the reference and impaired watersheds. Hydrology calibration results and the modeled time period for reference watersheds are given in Figures 5.1, 5.2, 5.3 and 5.4. Differences between observed and modeled flows in these watersheds are likely due to inherent errors in flow estimation procedures based on normalization for watershed size and possibly due to the proximity of the location of the weather stations.

Table 5.3 GWLF flow calibration statistics

Modeled Watershed	Simulation Period	R2 (Correlation) Value	Total Volume % Error
Walker Creek (USGS gage 03173000)	4/1/80 - 3/31/00	0.71	14%
Cedar Creek	4/1/88 - 3/31/89	0.92	10%
Hall/Byers Creek	4/1/88 - 3/31/89	0.90	9%
Hutton Creek	4/1/88 - 3/31/89	0.91	6%

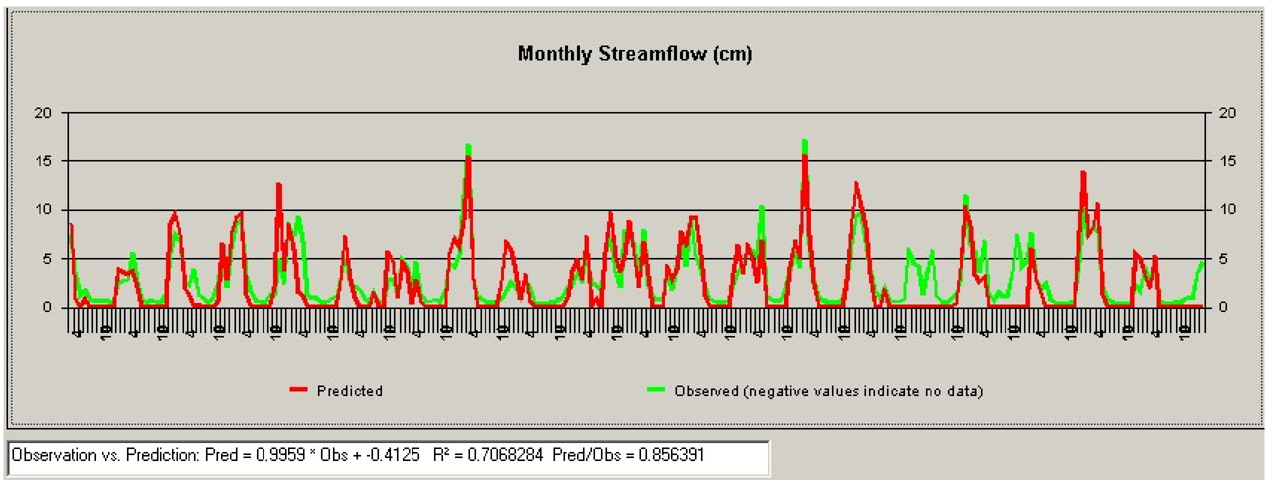

Figure 5.1 Hydrology calibration - Walker Creek at USGS gage 03173000 (4/1/80 - 3/31/00)

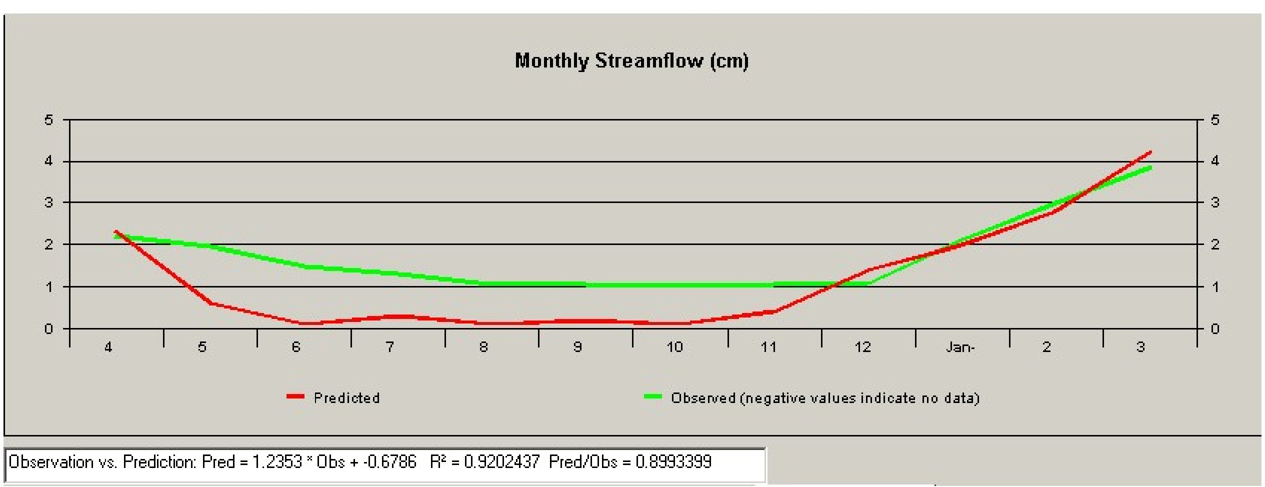

Figure 5.2 Hydrology calibration - Cedar Creek using USGS gage 03473500 (4/1/88 - 3/31/89)

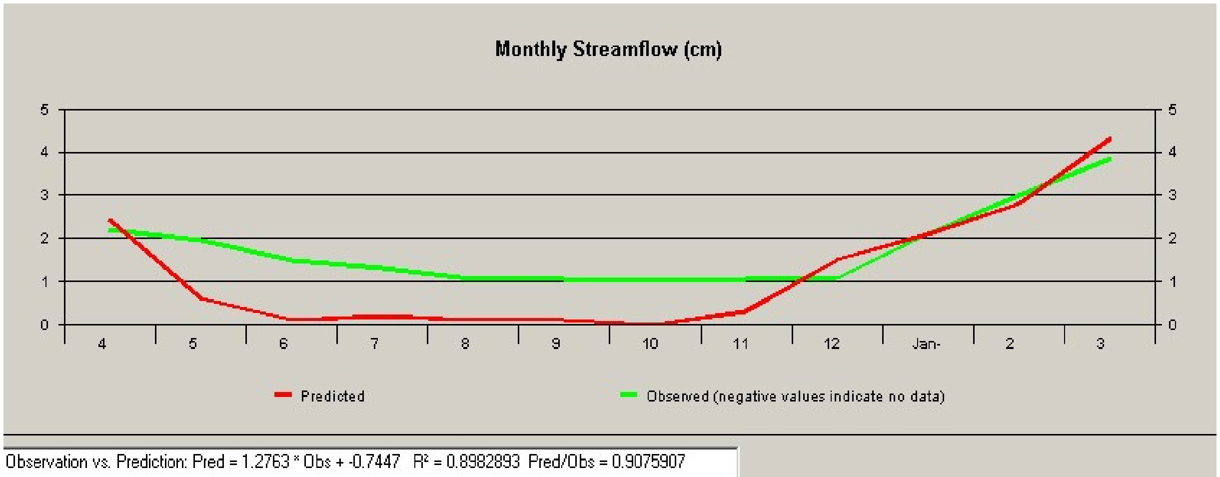

Figure 5.3 Hydrology calibration - Hall/Byers Creek using USGS gage 03473500 (4/1/1988 - 3/31/89)

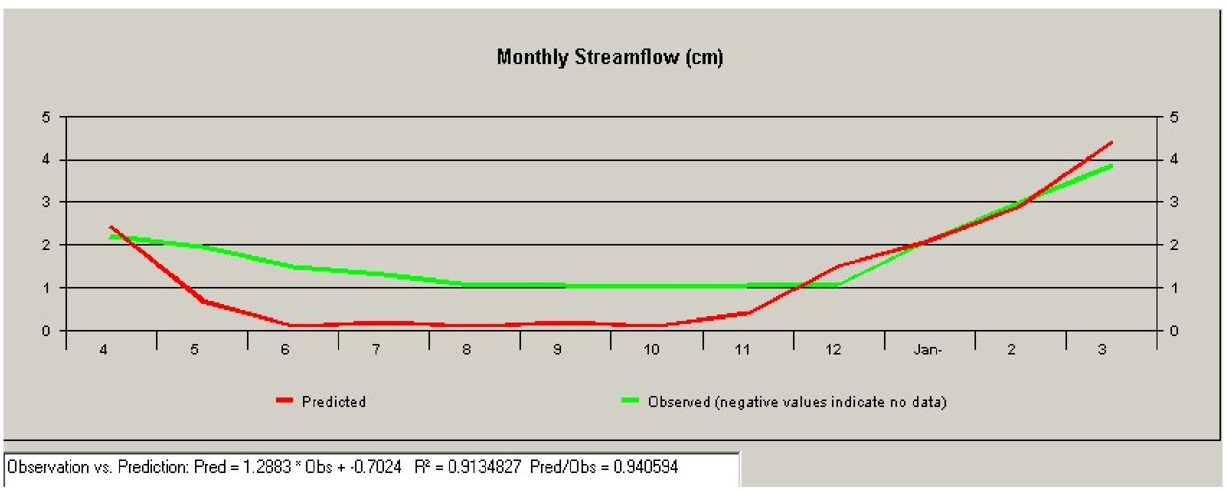

Figure 5.4 Hydrology calibration - Hutton Creek using USGS gage 03473500 (4/1/88 - 3/31/89)

SECTION 6

TMDL METHODOLOGY

6.1 TMDL Calculation

Impaired and reference watershed models were calibrated for hydrology using different modeling periods and weather input files. To establish baseline (reference watershed) loadings for sediment the GWLF model for Walker Creek were used. For TMDL calculation both the calibrated reference and impaired watershed were run for a 9-year period from (4/1990 to 3/2000). This was done to standardize the modeling period. Based on the weather and limited flow data it is assumed that this period will capture sufficient hydrologic and weather conditions. In addition, the total area for the reference watershed was reduced to be equal to its paired target watershed, as discussed in Section 5.3. This was necessary because watershed size influences sediment delivery to the stream and other model variables.

The 9-year means for pollutants of concern were determined for each land use/source category in the reference and the three impaired watersheds. The first year of each model run was excluded from the pollutant load summaries because the GWLF model takes a few months in the first year to stabilize. Model output is only presented for the years following the initialization year, although the model was run for a ten year time period. The existing average annual sediment loads for Cedar Creek, Hall/Byers Creek, and Hutton Creek are presented in Table 6.1.

Transport loss estimates were used to determine the total sediment load contributed by point sources in the Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds. The sediment delivery ratio calculated for each of these watersheds were used to estimate sediment transport losses caused by deposition, removal, and other in-stream processes. The inverse of this ratio was used because point source loads are directly contributed to the stream with no overland loss, as with land-based loads. The sediment delivery ratios used to determine the sediment loads from point sources in Cedar Creek, Hall/Byers Creek, and Hutton Creek were 81%, 84%, and 82.5%, respectively.

Note that the VADCR land use coverage used in TMDL development did not account for the Holston River SWCD BMP implementation efforts in these watersheds to date. Many of these BMP activities, including riparian restoration efforts, have improved benthic conditions in the Three Creeks watersheds. It is expected that some reduction in sediment loading has already occurred due to this successful program.

Table 6.1 Existing sediment loadings in Cedar Creek, Hall/Byers Creek, and Hutton Creek*

	Cedar Creek		Hall/Byers Creek		Hutton Creek	
Source Category	**Sediment Load (lbs/yr)**	**Sediment % of Total**	**Sediment Load (lbs/yr)**	**Sediment % of Total**	**Sediment Load (lbs/yr)**	**Sediment % of Total**
Cropland	2,831,949.76	64.17%	3,769,180.07	50.35%	2,440,841.38	46.93%
Pasture/Hay	1,566,804.72	35.50%	3,667,647.17	48.99%	2,759,084.73	53.05%
Transitional	12,233.36	0.28%	0.00	0.00%	N/A	N/A
Forest	19.59	0.00%	91.44	0.00%	75.59	0.00%
Water	0.00	0.00%	0.00	0.00%	0.00	0.00%
Urban (grouped pervious & impervious areas)	605.43	0.01%	1,000.43	0.01%	843.07	0.02%
Groundwater	0.00	0.00%	0.00	0.00%	0.00	0.00%
Point Source	1,444.65	0.03%	48,236.08	0.64%	75.38	0.00%
Total Existing Load	4,413,057.51		7,486,155.19		5,200,920.15	

**Note that the sediment loads are at the mouth of the watershed*

The TMDLs established for Cedar Creek, Hall/Byers Creek, and Hutton Creek consist of a point source wasteload allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The sediment TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek were based on the total load calculated for the Walker Creek watershed (area adjusted to the appropriate watershed size).

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. An explicit MOS of 10% was used in TMDL calculations to provide an additional level of protection for designated uses.

TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek were calculated by adding reference watershed loads for each pollutant of concern together with point source loads to give the TMDL value (Table 6.2). Note that the sediment WLA values presented in the following tables represent the sum of all point source WLAs in each watershed, minus in-stream transport loss (as described on page 6-1).

Table 6.2 TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek*

Watershed	Pollutant	TMDL (lbs/yr)	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	Overall %
Cedar Creek	Sediment	3,071,126.53	2,764,008.23	1,444.65 (*Meadowview Elementary School =1,179.31 Dillow's Shop and Wash =265.34*)	307,121.16	37.37%
Hall/Byers Creek	Sediment	5,564,960.98	4,964,969.22	48,236.08 (*Emory-Meadowview WWTP =48,236.08*)	551,755.68	33.68%
Hutton Creek	Sediment	4,306,346.62	3,875,553.87	75.38 (*Smith Residence, SFH STP = 75.38*)	430,717.37	25.48%

**Note that the sediment TMDL loads are at the mouth of the watershed*
*** Note that the overall % reduction is applied to the TMDL load exclusive of the MOS*

6.2 Waste Load Allocation

Waste load allocations were assigned to each point source facility in the watersheds. Point sources were represented by their current permit conditions and no reductions were required from point sources in the TMDL. Current permit requirements are expected to result in attainment of the WLAs as required by the TMDL. Point source contributions, even in terms of maximum flow, are minimal. Therefore, no reasonable potential exists for these facilities to have a negative impact on water quality and there is no reason to modify the existing permits. Note that the sediment WLA values presented in the following tables represent the sum of all point source WLAs in each watershed, minus in-stream transport loss (as described on page 6-1).

6.3 Load Allocation

Load allocations were assigned to each source category in the watersheds. The recommended scenarios for Cedar Creek, Hall/Byers Creek, and Hutton Creek (Table 6.3) are based on maintaining the existing percent load contribution from each source category. Two additional scenarios were considered, but due to the minimal amount of sediment loading from urban lands in each watershed, options were limited to the recommended scenario. The recommended scenarios balance the reductions from agricultural and urban sources by maintaining existing watershed loading characteristics. The loadings from source categories were allocated according to their existing loads distribution. For instance, sediment loads from forest lands represent the natural condition that would be expected to exist; therefore, the loading from forest lands was not reduced.

Note that streambank erosion loads were not calculated separately due to the lack of available data. Agricultural production has caused streambank erosion along several stream sections in these watersheds; therefore, TMDL implementation should include streambank stabilization measures which can lead to a significant reduction in sediment loads in these watersheds.

Table 6.3 Recommended sediment allocations for Cedar Creek, Hall/Byers Creek, and Hutton Creek*

	Cedar Creek		Hall/Byers Creek		Hutton Creek	
Source Category	**Sediment Load Allocation (lbs/yr)**	**Sediment % Reduction**	**Sediment Load Allocation (lbs/yr)**	**Sediment % Reduction**	**Sediment Load Allocation (lbs/yr)**	**Sediment % Reduction**
Cropland	1,750,144.95	38.20%	2,487,658.85	34.00%	1,805,246.28	26.04%
Pasture/Hay	999,621.41	36.20%	2,427,982.43	33.80%	2,069,313.55	25.00%
Transitional	12,172.20	0.50%	0.00	0.00%	N/A	N/A
Forest	19.59	0.00%	91.44	0.00%	75.59	0.00%
Water	0.00	0.00%	0.00	0.00%	0.00	0.00%
Urban (grouped pervious and impervious areas)	605.43	0.00%	1,000.43	0.00%	843.07	0.00%
Groundwater	0.00	0.00	0.00	0.00%	0.00	0.00%
Point Sources (WLA)** Existing load minus transport loss	1,444.65	0.00	48,236.08	0.00%	75.38	0.00%
TMDL Load (minus MOS)	2,764,008.23		4,964,969.22		3,875,553.87	

**Note that the sediment allocations are at the mouth of the watershed*
***Note: WLAs represent the existing permitted load from each facility minus the estimated sediment transport loss. Therefore, the allocation load given for each point source facility is equal to the existing, permitted load (no reduction).*

6.4 Consideration of Critical Conditions

The GWLF model is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is usually a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

6.5 Consideration of Seasonal Variations

The continuous-simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The combination of these model features accounts for seasonal variability

SECTION 7

REASONABLE ASSURANCE AND IMPLEMENTATION

7.1 Reasonable Assurance

Sediment reductions in the TMDLs are allocated according to the source loading characteristics for each watershed. Implementation of best management practices (BMPs) in the affected areas should achieve the loading reduction goals established in the TMDLs. The fecal coliform bacteria implementation plan that was developed by the Commonwealth of Virginia in 2001 should result in substantial reductions in sediment loading through shared BMPs (VADCR 2001). Substantial reductions in the amount of sediment reaching the streams can be made through the planting of riparian buffer zones, contour strips, and cover crops. These BMPs range in efficiency from 20% to 70% for sediment reduction. Other possibilities for attaining the desired reductions in sediment include stabilization of stream banks and stream fencing. Further "ground truthing" will be performed in order to assess existing BMPs, and to determine the most cost-effective and environmentally protective combination of future BMPs required for meeting the sediment reductions outlined in this report.

Note that the VADCR land use coverage used in TMDL development did not account for the Holston River SWCD BMP implementation efforts in these watersheds to date. Many of these BMP activities, including riparian restoration efforts, have improved benthic conditions in the Three Creeks watersheds. It is expected that some reduction in sediment loading has already occurred due to this successful program.

7.2 Follow-Up Monitoring

The Department of Environmental Quality will maintain the existing monitoring stations in these watersheds in accordance with its ambient monitoring program. VADEQ and VADCR will continue to use data from these monitoring stations to evaluate improvements in the benthic communities and the effectiveness of the TMDL in attaining and maintaining water quality standards.

7.3 Regulatory Framework

This TMDL is the first step toward the expeditious attainment of water quality standards. The second step will be to develop a TMDL implementation plan, and the final step is to implement the TMDL until water quality standards are attained. An implementation plan was previously developed to address the bacteria impairment on each stream (VADCR 2001).

Section 303(d) of the Clean Water Act (CWA) and current EPA regulations do not require the development of implementation strategies. However, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) directs VADEQ in section 62.1-44.19.7 to "develop and implement a plan to achieve fully supporting status for impaired waters". The Act also establishes that the implementation plan shall include that date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated cost, benefits and environmental impact of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process". The listed elements include implementation actions/management measures, time line, legal or regulatory controls, time required to attain water quality standards, monitoring plan and milestones for attaining water quality standards. Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of VADEQ, VADCR and other cooperating agencies.

Once developed, VADEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan, in accordance with the CWA's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and VADEQ, VADEQ also submitted a draft Continuous Planning Process to EPA in which VADEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

7.4 Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. In response to the federal Clean Water Action Plan, Virginia developed a Unified Watershed Assessment that identifies watershed priorities. Watershed restoration activities, such as TMDL implementation, within these priority watersheds are eligible for Section 319 funding. Increases in Section 319 funding in future years will be targeted towards TMDL implementation and watershed restoration. Other funding sources for implementation include the USDA's CREP program, the state revolving loan program, and the VA Water Quality Improvement Fund. Funding sources should also provide for streambank stabilization efforts to reduce sediment loads from this source.

7.5 TMDL Implementation

Implementation of best management practices (BMPs) in the watersheds will occur in stages. The benefit of staged implementation is that it provides a mechanism for developing public support and for evaluating the adequacy of the TMDL in achieving the water quality standard. Implementation of these TMDL will also contribute to on-going water quality improvement efforts in these watersheds.

7.6 Water Quality Standards

If implementation of reasonable BMPs has failed to improve or restore the benthic community and additional controls would have widespread social and economic impacts, VADEQ has the option of performing a Use Attainability Analysis (UAA) using the factors set forth in 40 CFR ' 131.10(g). A UAA is a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in the Federal Regulations. The primary factors to include are as follows: 1. the factor of widespread social and economic impacts 2. human caused conditions and sources of pollution prevent the attainment of the use and cannot be remedied. The stakeholders in the watershed, Virginia, and EPA will have an opportunity to comment on these special studies.

SECTION 8

PUBLIC PARTICIPATION

The first public meeting on the development of TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek was held on January 27, 2003 from 7-10 p.m. at Patrick Henry High School in Glade Spring, Virginia. Copies of the presentation materials were made available for public distribution at the meeting. No written comments were received.

The second public meeting on the development of TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek was held on September 23, 2003 from 7-10 p.m. at Patrick Henry High School. Copies of the Draft TMDL report and presentation materials were made available for public distribution at the meeting. Written comments were received from the Washington County Service Authority and the New River-Highlands RC&D. Additional discussion regarding streambank erosion and BMP implementation measures that would help meet the sediment load reductions required in these TMDLs was added to the Final TMDL report.

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